ANALYSIS OF FORWARD CONTRACTING BY CALIFORNIA DAIRY PRODUCERS ON INPUT AND OUTPUT SIDES USING LEAST-COST AND PROFIT-MAXIMIZATION METHODS

by

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ABSTRACT

Economically optimized ration formulations were used to test whether California dairy producers who implemented price risk management strategies on both the input and output sides achieved significantly higher net returns as measured by milk income minus feed costs compared to producers who bought feed and sold milk on the spot market. Two ration formulation models were developed, a least cost and a profit-maximization. The least cost method formulates a ration that meets the nutritional requirements of a lactating cow at the lowest possible cost for a given level of milk production. The profit maximization model incorporates into its algorithm a production function between net energy intake and milk production that increases at a decreasing rate. For today's high producing cows, after being supplied with enough energy to meet maintenance requirements, all additional energy is partitioned for milk production. Up to a certain point, depending on the price of milk and the price of feed, the cost of providing additional feed units is more than offset by the revenues derived by the extra milk produced from the larger quantities of feed consumed. The profit-maximization model used formulates a ration using both feed and milk prices where the cost of the last unit of feed provided is equal to the revenues of the last unit of milk produced.

To compare returns, a ration program was designed that could either use spot or forward values for feed costs and milk price to economically optimize the ration on a weekly basis in the cow's milk production cycle. To better gauge the impact of price volatility on both the input and output sides and to account for the extended nature of the forward contracts, the 305-day lactation cycle of a high producing cow over six successive cycles was used. The federal order Class III milk price was used for milk values and it was

assumed that unless the producer engaged in some sort of forward contract, the milk price received was the monthly Class III value. To account for forward sales, the Class III futures contract traded at the Chicago Mercantile Exchange was used. For the feed prices, the ration model had a library of 16 different ingredients, 11 of which had forward and spot values. Similar to the output side, it was assumed that unless the producer engaged in some sort of forward contract the feed price used was the spot value averaged for each month.

Most California dairy operators use some version of the least-cost method when formulating their rations. A large number also forward contract a significant portion of their feed as the concept of forward contracting feed is much more common in the western U.S. as compared to other regions in the country. Conversely, there has been little interest in locking in future milk prices as the tools for forward contracting are relatively new and many producers are not familiar with the mechanics. This helps explain the limited use of the profit-maximization model since milk prices are an integral part of this process. Results of this study show that producers who formulate using the profit-maximization model attain higher milk production and derive higher milk revenues, albeit with higher feed costs. Nonetheless, across every situation, that is whether one forward contracts feed, milk, or some combination thereof the profit-maximization model returned anywhere from $0.14 to $0.19 of milk revenues in excess of feed costs per hundredweight of milk as opposed to the least-cost method. For a producer milking 1,000 cows this represents another $50,000 to $70,000 of income per year. The results also show that whether least-cost or the profit-maximization method is employed, feed costs were lower when producers forward contract at least a portion of their needs. Milk prices, on the other hand, were lower relying on the spot market as opposed to either of the two forward milk contracting models that were developed. Finally, the variability of returns as measured by the coefficient of variability show less volatility in revenues when producers forward contract milk and less variability with input costs when producers forward contract feed.

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CHAPTER I: INTRODUCTION

1.1 Problem Statement

Dairy and other agricultural producers confront a variety of risks in managing their operations. Price, production, financial, legal and human resources are all sources of risk. The purpose of this thesis will focus on price risk, both on the input and output sides, and how dairy managers can try to manage these risks. Over the past two decades, U.S. agricultural policy has begun to dismantle the myriad of support programs for basic farm commodities that have existed since the Great Depression. As a consequence, the past few Farm Bills have provisions that emphasize the need to produce based on anticipated market returns as opposed to adhering to any federal program. Furthermore, the large government stockpiles of many agricultural commodities such as grain and powdered milk that were seen in earlier years have been sharply reduced. So while there is no longer a need to maintain costly inventories, there is no cushion of supplies should a production shortfall occur. It is primarily these two factors that have contributed to increased volatility for both feed and milk prices. For dairy producers, profits are maximized with increased revenues and lower costs so the most favorable scenario is when milk prices are high and feed prices low. There are times, however, when milk prices are depressed and feed values very expensive. An extended period of such conditions can cause severe financial hardships and jeopardize the viability of the operation. There are a number of tools that producers have at their disposal to help manage these price fluctuations including cash forward contracts and exchange traded options and futures for both the feed input and the milk output risks. It is therefore incumbent that producers employ better use of the price risk management tools that currently exist.

The purpose of this paper is to compare estimated returns to producers who employ various risk management strategies versus those that buy feed and sell milk on the spot market. To compare returns, two different ration formulation programs were designed; a least-cost model and a profit-maximization model that could use either spot or forward values for feed and milk prices with rations formulated on a weekly basis. To better gauge the impact of price volatility on both the input and output sides and to account for the extended nature of the forward contracts, formulations were optimized for six consecutive 305-day lactation cycles of a high producing cow covering the period August 1999 through August 2004. For milk values, the federal order Class III price was used and it was assumed that unless the producer engaged in some sort of forward contract, the milk price received was the monthly Class III value. To account for the forward sales, the Class III futures contract traded at the Chicago Mercantile Exchange was used. The Federal government has four classes of milk that are used to calculate producer milk prices throughout the country. Class I is for fluid milk, Class II is for the use in the manufacture of soft cheeses and yogurt, Class III is for milk used in the manufacture of hard cheeses, and Class IV is for use in the manufacture of butter and non fat dry milk. Most milk in the U.S. is used for the production of hard cheeses so Class III prices are most influential in determining producer milk revenue throughout the U.S. California is actually the only state that is outside the Federal market order system, though similar to other regions of the country, the milk price received, known as the over-base is based on a mix of the various classes of milk. Of particular note is the high correlation between the California over-base price and the Federal Class III value. With a correlation in excess of 94%, Class III milk futures are a very effective hedge vehicle for California milk producers.

For forward contracting purposes, the benchmark established is the five-year rolling average plus one standard deviation of the Federal Milk Marketing Order Class III monthly cash price. This benchmark was chosen so the producer could, if possible, sell milk at values in the upper 16.5% of the range in prices seen over the past five years. For forward contracting purposes, the nearest 12 months of Class III futures contract data along with the three month, six month, and twelve month strips (consecutive months) of futures prices were used. Two separate forward contracting models were devised, one that used strips of futures (Strips Months Model or SMM), and the other that used the individual futures months (Individual Months Model or IMM). If either the individual months or strips of futures exceeded the forward contracting benchmark then a forward contract was initiated otherwise the actual cash Class III price was used.

On the input side, the ration formulation model had a library of 16 different ingredients, 11 of which had forward and spot values. Similar to the output side, it was assumed that unless the producer engaged in some sort of forward contract the feed price used was the monthly average spot value. The benchmark here was the rolling five-year average less one-half a standard deviation of each individual ingredients monthly cash price. This benchmark was chosen to allow the producer to forward contract a specific feed ingredient at a price lower than the five-year average if possible. Feed ingredients could be forward contracted from one to 18 months out if the forward contracted value was equal to or less than the established benchmark price. Formulating with either the profit-maximization or the least-cost methods, using either spot or one of the milk forward contract prices, and using either spot or forward feed values resulted in 12 different strategies that were examined and results generated for. They include;

1. Least-cost formulation with spot milk and spot feed values
2. Profit-maximization formulation with spot milk and spot feed values
3. Least-cost formulation with three, six or twelve month strips of forward milk values and spot feed values. The three, six or twelve month strips of forward milk values will hereby be referred to in this paper as the Strips Months Model or SMM.
4. Profit-maximization formulation with SMM values and spot feed values
5. Least-cost formulation with individual months of forward milk values and spot feed values. The individual month's method of obtaining forward milk values will hereby be referred to in this paper as the Individual Months Model or IMM.
6. Profit-maximization formulation with IMM values and spot feed values
7. Least cost formulation with spot milk and forward feed values
8. Profit-maximization formulation spot milk and forward feed values
9. Least-cost formulation with SMM milk values and forward feed values
10. Profit-maximization formulation with SMM milk values and forward feed values
11. Least-cost formulation with IMM milk values and forward feed values
12. Profit-maximization formulation with IMM milk values and forward feed values

1.2 General Objective

In this paper, net returns of a typical California dairy producer measured by milk revenues minus feed costs are examined under a variety of scenarios. Most California dairy producers forward contract some or all of their feed ingredients depending on the current price being offered and their outlook for the future price of a particular feed ingredient. They also have the choice of going on the spot market and buying their ingredients on an as needed basis. Here they are at least guaranteed the average price for the year, for often, spot values will be higher or lower than values associated with forward contracts depending on whether that particular feed ingredient exhibits an inverted or carry market structure. On the milk side, the vast majority of producers do not enter into forward milk contracts and even fewer utilize the exchange traded options and futures markets to help establish a set price for the future. The spot milk prices used in this paper are based on the Federal Class III value while the forward milk prices use the futures contracts associated with this cash contract. California is unique in that its milk pricing system is the only one in the country not part of the Federal Milk Marketing Order. Both the Federal and California systems use the value of the manufactured products, butter, cheese, dry whey, and non-fat dry milk to determine the monthly milk prices. The correlation between the Class III and the California over-base, the price which California dairy producers actually receive, is quite high so the Class III futures contract can be an effective tool to forward contract milk. Figure 1.1 shows the correlation between the California over-base and Federal Class III from January 1995 to December 2004 was 90.3% and an even higher 94.4% for the more recent five-year period January 2000 to December 2004.

Using a database of spot and forward feed and milk prices, ration formulations were optimized that generated returns as measured by income minus feed costs involving a number of different scenarios. Feed and milk values used came from a 264 week study with prices observed from the first week of August, 1999 to the last week of August 2004. This study period allowed sufficient length of time to gauge the impact of forward contracting for both milk price series and nine out of the sixteen feed ingredients. In the model, the milk and feed price used defaults to the spot price unless feed and/or milk prices are already fixed via a forward contract being employed. The model formulates a ration using either a least-cost or profit-maximization program. Most rations today use the least-cost method where a mix of ingredients is chosen that satisfy the minimum necessary nutritional requirements of a dairy cow at the least possible price for a given level of milk production. The problem here is that even though this is the lowest possible price, it is still not known whether it is the most profitable ration. Today's dairy cows produce increasing volumes of milk given specified quantities of feed as opposed to their predecessors. This is based on superior genetics, increased nutritional knowledge, and enhanced management techniques. For that reason incremental units of feed will generate even higher milk production. The profit-maximization model is an optimization model that will formulate a ration that results in the revenue from the last unit of milk produced to be equal to the costs of the feed needed to generate that last incremental unit of milk. The variables needed to solve this optimization problem include the price of various feeds, the quantities of feed fed, the milk produced, and the price of that milk sold. The least cost formulation program uses only the quantity of feed and the price of feed to arrive at a ration whereas the profit-maximization process utilizes both the feed and milk components. For both formulations, the specifics for the 305-day lactation cycle are drawn from the National Research Council (2001). The milk production cycle of an “average” cow is used along with associated values for dry matter intake, net energy requirements, and pounds of milk produced per day. Comparisons of net returns using these ration formulations with and without forward contracts for feed and milk are made. The net returns from using the least-cost model versus returns estimated by the profit-maximization model are compared as well. Standard deviation and coefficient of variation statistics are used to measure the variability of net returns for feed costs, feed consumption, milk production and milk revenues.

To summarize, the objectives of this paper are to compare the net returns and variability of return for dairy producers who selectively utilize price risk management tools to those producers that use only spot feed and milk prices. Second is to further analyze whether a more traditional least-cost model or a profit-maximization model provides higher net returns.

1.3 Specific Objectives

The specific objectives are:

I. Obtain data to determine the relationship between net energy from feed ingredients and milk production for a high producing cow. Feed ingredients have various quantities of nutritional components including energy, protein, fiber, minerals, and vitamins. It has been determined that the amount of net energy consumed is the main limiting factor for milk production (Blaxter, 1962). Therefore, the relation between net energy intake and milk production is important in this study.

II. Establish a milk production function that specifies the relationship between feed inputs and the output of today's high performance cows. After a cow satisfies its maintenance requirements, all net energy consumed is directed toward milk production. The milk production function exhibits diminishing marginal returns. As more increments of feed are used milk production increases at a decreasing rate.

III. Design a model to derive the least-cost feed ration which meets the minimum net energy requirements for each day in a 44-week lactation cycle. A typical high producing cow goes through a 44-week or 305-day lactation cycle with her body weight, milk-fat percent, and pounds of milk per day dependent on the week of lactation. These factors help determine how much dry matter intake a cow consumes per day and this will dictate how much net energy is consumed. A least-cost model formulates a ration that will satisfy the cow's net energy and crude protein requirements for a given level of milk production at the least possible cost.

IV. Using a least-cost ration formulation model, calculate the amount of milk produced per day.

V. Determine the net return per day using the estimated milk production, the applicable milk price, and the total costs of the feed ingredients that were chosen by the least-cost formulation model.

VI. Determine the total net return for the 44-week lactation period and along with the average daily milk production, net energy consumed, milk revenues, feed costs, and average daily return using the least-cost model.

VII. Develop a profit-maximization model that selects the level of milk production that maximizes the difference between milk revenues and feed costs for each day of the 44-week lactation cycle. The estimated milk production function is based on the relationship between net energy intake and milk production (Blaxter, 1962). As opposed to the least-cost approach, the price of milk is an important factor in this optimization model.

VIII. Calculate the daily net return using the profit-maximization model, the feed mix and milk produced each day.

IX. Determine the total net return for the 44-week lactation period and along with the average daily milk production, net energy consumed, milk revenues, feed costs, and average daily return using the profit-maximization model.

X. Compare the results from the cost-minimization model to that of the profit-maximization model in terms of net energy, crude protein, and dry matter intake per day, the amount of milk produced, milk revenues, total feed costs, and profit (milk revenues - feed costs) on a per day basis.

XI. Repeat objectives IV, V, VI, VIII, IX, and X when feed costs are forward contracted.

XII. Repeat objectives IV, V, VI, VIII, IX, and X when milk prices are forward contracted.

XIII. Repeat objectives IV, V, VI, VIII, IX, and X when feed costs and milk prices are forward contracted.

XIV. Compare results from the cost-minimization model to those of the profit-maximization model for all strategies including those where spot prices were used and then combinations of spot and forward values for both feed costs and milk prices. Comparisons are also made for net energy, crude protein, and dry matter intake per day, the amount of milk produced, milk revenues, total feed costs, and profit (milk revenues - feed costs) on a per day basis. In addition, the coefficient of variation figures for net energy, crude protein, dry matter intake, milk production, milk revenues, total feed costs, and profit for the 264 week study period for all strategies are reported.

Table 1.1 outlines the twelve strategies that are examined. Rations are determined using either the least-cost or profit-maximization model. Feed prices can either be the spot values for each of the 16 ingredients in the feed library or forward values for the 11 feed ingredients where forward contracting was possible. Milk can be priced using either the spot or the monthly Class III value or either of the two forward contracting methods. The first is the Strips Months Model or SMM that uses three, six, or twelve consecutive months of Class III milk futures that are averaged together to form a strip. The other is the Individual Months Model or IMM that uses individual futures months.

1.4 Rational

California is the largest dairy producing state in the nation with more than 1.90 million cows. Similar to other Western states, the number of cows per operation is quite large with 2009 figures from the USDA (2010) and the California Department of Food and Agriculture (2009) showing California averaging over 950 animals per operation compared to 140 for the U.S. as a whole. These large numbers of animals are arranged in strings or groups dependent on the cow's age and stage of lactation. The operations of a typical California dairy are quite complex and the challenges for any owner are immense. All producers face a number of legal, human resource, financial, production, and price risks. This paper deals with the issue of price risk, specifically the impact of higher than expected feed costs and lower than expected milk values. Any successful manager will use tools to help minimize the impact of such risks. Lawyers are used to address legal and human resource issues while bankers and accountants work on areas of financial risk. Nutritionists, veterinarians, and construction engineers are some of those involved to help maintain high milk production. The identification of price variability as a source of risk to the operation and developing tools to help minimize said risk is actually relatively new to the dairy industry. As mentioned earlier, it has only been in recent years that milk and feed prices have exhibited increased price variability. In order to help reduce this volatility and attract customer business, both feed companies and the various milk processors and coops have begun to offer their customers cash forward contracts to lock in favorable feed and milk prices for the future when they occur. Similarly, there are a variety of exchange traded derivative instruments, specifically futures and options for grain and milk that can also be used to help lock in forward feed input and milk output values.

When assessing risk, the producer must ask how likely is an adverse event going to affect my operation, and if so, how severe will its impact be. For instance, corn is a major component of a typical California dairy ration, often accounting for up to 25% of the total volume of feed consumed per day. If the price were to rise from $110 per ton to $120 that is not too much of a shock and most likely would not have much impact on the finances of this enterprise. On the other hand, should prices double to $200 per ton that would have a much more adverse effect on the operation, particularly if corn prices were to stay at these high levels for an extended period of time. A similar situation would apply with milk prices if they dropped substantially, well below what some would consider the break-even price. Producers do have large risk from an extended period of high feed costs, low milk prices, or a combination of both. MacDonald (2007) indicates that about half of all large western dairy producers forward contract a good portion of their feed. However, most do not do this for risk management. Rather they do not want to be bothered buying on the spot market on a daily, weekly, or monthly basis. The vast majority of producers do not manage milk price risk, feeling that since they receive a milk check every month they will get the average price for the year. Furthermore, the cash forward milk contracts offered by the various processors and creameries, milk futures contracts and options are relatively new. Most producers have very little understanding of the mechanics and concepts of pricing their milk for future delivery. Given these conditions there is a need for research that examines risk management strategies for milk production.

1.5 Organization of Thesis

Chapter Two of this thesis reviews the literature as it pertains to milk production functions, the least-cost ration model, and the profit-maximization ration model. Literature relevant to the study of feed cost risk reduction and milk price risk reduction is also reviewed. Chapter Three is devoted to economic theory on milk production along with the cost-minimization and profit-maximization approaches to ration formulations. It also presents a discussion of why one approach has traditionally been followed and why a producer would be interested in strategies that seek to reduce feed and milk price risk. This is followed by an examination of the decision criteria used to analyze the results. Chapter Four presents the procedures and data. It begins with an overview and then provides a complete description of both the cost-minimization and profit-maximization models. A description of the twelve strategies examined is provided. Data for the milk production function, feed ingredients, and milk pricing are presented and summarized. Chapter Five presents the results. Chapter Six summarizes the analysis and provides some conclusions. Additional areas for further research are also discussed.

Table 1.1: Twelve Feed and Milk Contracting Strategies

Strategy Code	Model	Feed Prices	Milk Prices
A	Least Cost	Spot[1]	Spot
B	Profit Maximization	Spot	Spot
C	Least Cost	Spot	SMM[2]
D	Profit Maximization	Spot	SMM
E	Least Cost	Spot	IMM[3]
F	Profit Maximization	Spot	IMM
G	Least Cost	Forward[2]	Spot
H	Profit Maximization	Forward	Spot
I	Least Cost	Forward	SMM
J	Profit Maximization	Forward	SMM
K	Least Cost	Forward	IMM
L	Profit Maximization	Forward	IMM

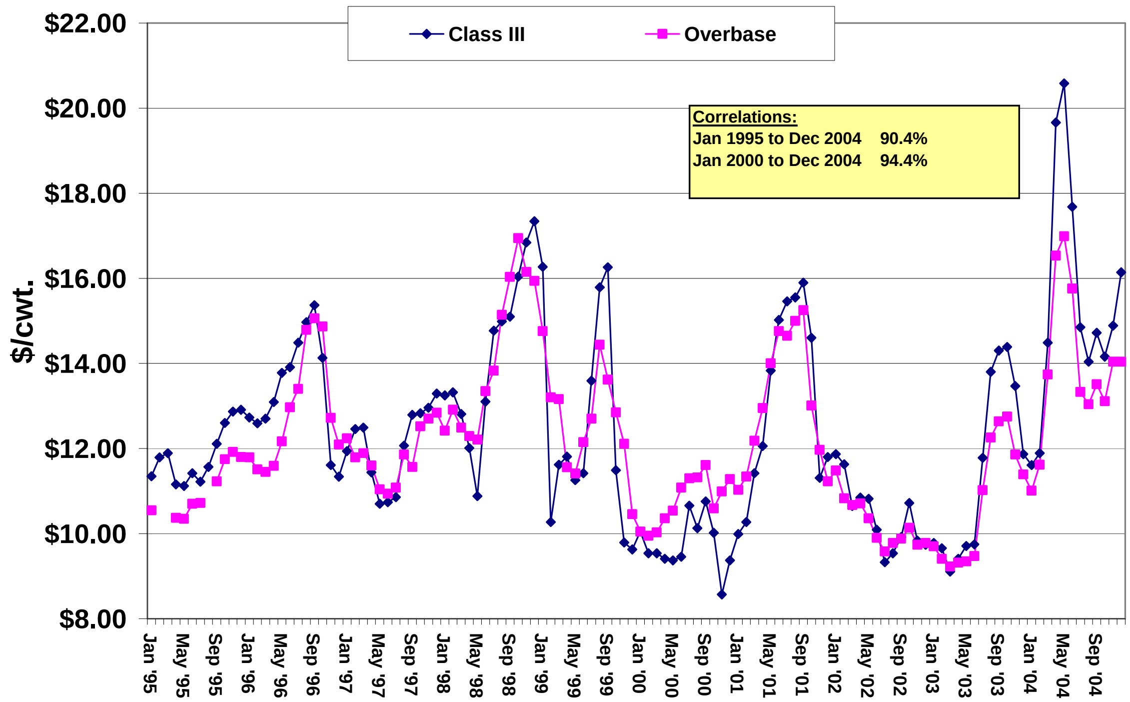
[1] Spot refers to a feed bought or milk sold on cash market

[2] Forward-refers to feed bought or milk sold at forward contracted price.

[3] SMM- refers to forward contracts of milk sold using strips of futures.

[4] IMM- refers to forward contracts of milk sold using individual months of futures

Figure 1.1: California Overbase vs. U.S. Class III Milk Prices with Correlations.



CHAPTER II: REVIEW OF LITERATURE

2.1 Milk Production Function

A key component of this paper is the implicit understanding of the milk production function. A study done by Blaxter (1962) showed how higher levels of total estimated net energy intake led to increasing levels of milk production. Trials run at the University of California, Davis as detailed by Dean et al. (1972) closely approximated Blaxter's work. The authors developed the first commercially feasible computerized linear programming model for maximizing income above feed costs for dairy cattle. The program chose the concentrate mix, the roughage mix, concentrate-roughage ratio, quantities of each fed, and the quantity of milk production that maximized net returns. Net return is defined as the value of milk production minus feed costs. Noteworthy is the fact that the model took into account the weight, stage of lactation, and productive ability of the individual or string of cows. The authors indicated that a major weakness in their linear programming model was a lack of basic knowledge about the production function relationships, especially with regard to the net energy-milk production relationship.

Agnew and Yan (2000) examined how animals respond to additional increments of feed and how that additional feed is partitioned between milk output and body tissue gain. The authors note that "only when we fully understand this partitioning relationship, and how it is influenced by both animal and feed factors, can sensible feeding practices be developed." They go on to say that unfortunately there have been too few attempts to address this issue fully. They speculate that the cow, in a number of ways including genetic ability, milk yield and composition, body condition, and stage of lactation, influences how additional increments of feed are partitioned. The feed itself may also influence partitioning via composition, degree of processing, or method of feeding. Despite these shortcomings, Agnew and Yan (2000) noted that it is well recognized that there is a curvilinear relation between feed input and milk output. After a cow satisfies its maintenance requirements, most of the net energy consumed is directed toward milk production. The milk production function exhibits diminishing marginal returns. There is a relation between feed input and milk output. As more increments of feed are used, milk production increases at a decreasing rate. The fact remains that this curvilinear relation for groups has been well documented and it is specifically the energy fraction of the ration that has been the focus of the partition debate. Today's high producing cows can give greater amounts of milk per unit of energy than in the past and they can also consume more feed.

This issue is discussed extensively by Vandehaar (1998) where today's milk cows consume more feed to support higher milk production yet digestive efficiency decreases as cows eat more. Even so, for high producing animals, biological efficiency increases as cows produce more milk up to about 33,000 pounds per year. Though feed costs increase with higher milk production, the increased productivity helps profitability based on increased efficiency and the fact that fixed costs decline as a percent of total costs. Vandehaar says this positive relation between productivity and profitability can continue up to 46,000 pounds of milk per cow per year. Biological efficiency is the increased digestive efficiency as higher feed intakes result in more feed being partitioned for milk production. Efficiencies are focused on the energy intake since that is the nutrient most limited to the dairy cow and that is the nutrient found most associated with milk production. It was noted that protein is a form of feed energy and is accounted for in the energy efficiency. All of the energy nutrients consumed are not all digested with some lost to fecal energy, urine, gas, and body heat. What is left, called net energy is used to support the cows maintenance functions or else directed toward milk production. Maintenance energy is defined as the energy required to sustain an animal's body tissue with no net change in body tissue. In other words, it is the amount of feed required so an animal is not gaining or losing weight. In cows, the efficiency of converting net energy to maintenance or lactation is the same so the only energy values needed are those for net energy of lactation, (NE_L). Vandehaar (1998) makes mention of the dilution of maintenance effect where after satisfying a cow's maintenance requirements, all extra energy is directed toward milk production. If a cow's maintenance requirements are 10 megacalories (Mcal) of NE_L per day and she consumes 20 Mcal then 50% of the NE_L is captured in milk while if she consumes 40 Mcal per day then 75% of the NE_L is captured. The dilution of maintenance concept assumes that each Mcal of NE_L above maintenance would be completely converted to milk though it was pointed out that this is seldom the case because there is diminishing marginal milk production. Also an increasing amount of NE_L is converted to body tissue gain at higher intakes, especially in the late stages of the lactation cycle. Another key component discussed in Vandehaar's paper is the fact that as feed intake increases, digestive efficiency is reduced. This can be a problem since Vandehaar feels that the NE_L values used in the *Nutrient Requirements for Dairy Cattle* publication (NRC, 2001) are assumed to overestimate the actual energy values of most feeds when they are fed to high producing cows. The NRC tables assume that most cows eat at a level three times maintenance. That is, cows consume three times the amount of feed needed to sustain normal body functions. High producing cows eat much more than that and the increased feed is not digested as efficiently. In fact models, including the one in this study, which incorporate the latest research on the milk production function, do account for the decreased digestibility as intake and milk production increase. If this is not accounted for, using the NRC values would imply milk production increases linearly as intake increases, which it does not. Efficiency continues to increase at a decreasing rate with diminished marginal milk production as intake increases. In fact models that incorporate a digestibility discount predict that marginal milk production decreases as intake increases above maintenance with the efficiency maximized at four to five times maintenance. The marginal milk production above this level of intake is zero or even negative.

Vandehaar (1995) indicates that profitability is not directly related to efficiency. As cows produce more milk they consume more expensive feed ingredients. Here a distinction is made between feed costs per unit of milk and milk income less feed costs with the latter tending to increase as milk production rises. As cows produce more milk that will necessitate more expensive rations being fed but the higher milk volumes produced may offset the increased feed expenditures. This will depend on the relative prices of feed and milk and the quantity of feed needed to produce the extra pounds of milk. However, increased milk production does generate increased non-feed costs including higher expenditures for labor and capital improvements.

2.2 Profit-Maximization Model

Starting in the early 1970's formulating dairy feed rations changed quite dramatically with the advent of computers as this made linear programming, i.e. solving for a solution to a number of equations simultaneously much easier. This led to the development of least cost formulations where a cows minimum nutritional requirements are satisfied at the least possible feed cost. Another development in the dairy industry at that time was the increasing use of a total mixed ration (TMR) where roughage and concentrates were fed together instead of the more common practice at that time of feeding grain in the milking parlors and hay elsewhere. This allowed one to tailor rations to different groups of cows depending on stage of lactation and the maturity of the cow. The increasingly sophisticated computers used in ration formulations and the advent of the TMR feeding system spawned some early interest in the concept of designing dairy rations other than with least-cost formulations. Research in this area was first conducted at the University of California, Davis where Bath, Hutton and Olson (1972) worked on such a program. They thought that by taking into account milk prices and the productive ability of cows it might be possible to formulate a ration that maximizes income over feed costs. A computer program was developed that included among its factors feed prices, milk prices, milk production with varying levels of nutrients such as energy, protein, fiber, calcium, and phosphorus, maximum voluntary feed intake, and the productive ability of the cows. In addition, the computer also returned the range of prices at which a particular feed ingredient would stay in the ration without changing the formula. This analysis could also provide the information on the feed ingredient price where their use would increase or decrease in the ration. For ingredients not chosen, the University of California, Davis program would also calculate the range of prices at which they would enter the formulations, commonly called shadow prices.

The Bath, Hutton and Olson study compiled nutritional requirements for dairy cows for both maintenance and lactation purposes from several sources, most notably from Morrison (1948). It was noted that although the nutritional requirements were based on prior research results, the feeding trials conducted by Bath the authors were the first ever using this type of profit-maximization model. In both a small scale test and a larger trial, there was a control group that was fed and managed in the same manner it had been prior to the onset of these experiments. The objective of these trials was to compare the milk production and relative economics of cows fed and managed according to the computer formulated rations vs. those that were managed according to prior practices. Two separate feed trials were run, the first a double reversal design using 12 cows done at the University of California, Davis extension facilities. The second was a more comprehensive field trial involving 180 cows at a vocational center. The bottom line was that cows fed the computer formulated rations returned \$15-\$21 more income above feed costs per year than cows fed the control ration formulated according to nutritional practices that had already been in place.

Bath and Bennett (1979) describe how the computer generated profit-maximization formula was improved upon and made available to a number of producers. In order to maximize income above feed costs, the program had data on 101 different feed ingredients with the ability to change certain nutritional specifications for each ingredient and to add additional feedstuffs. Input data were also included for cow weights, fat tests, response of milk production, milk prices, whether a cow was a first or second lactation animal, and of course prices for the available feeds, and minimum and maximum constraints on the various feed ingredients. The basic nutrient requirements for lactating dairy cows were taken from the NRC, 1978 edition. The basic nutritional requirements are for net energy for lactation (NEL), crude protein (CP), calcium (Ca), and phosphorus (P). These are linked to body weight, milk production, milk fat, and maintenance and the program has to solve for both minimum and maximum sets of feed constraints.

One of the key considerations of the profit-maximization model is its use of various milk production functions. Bath (1975) formulated a model where production functions were generated to accommodate milk production from less than 30 pounds per day to over 90 pounds with fat tests ranging from 3-6%. This allows the user of the model to select the best fitting production function based on the level of milk production and fat percent for an individual cow or group of cows. These response curves plot milk production on the y-axis and net energy on the x-axis. The curve starts off at some point along the x-axis with no milk production as a certain level of energy is needed just for maintenance purposes. As the amount of energy intake increases the response in milk production is even greater as just an incremental rise in energy consumed triggers a greater jump in milk production. Initially, for each additional unit of energy the increase in milk production is even greater. At some point, however, the rate of increase in milk production per unit of extra energy provided begins to decline. Eventually, the cost of providing the extra energy will equal the revenues of the additional milk generated. As additional net energy is consumed, the milk production curve plateaus and even declines as the extra energy will spawn a variety of feeding disorders. The most essential element then of profit-maximum formulation is that point on the milk response curve where the value of the next unit of milk equals the cost of energy needed to produce it and the computer formulates a ration for that level of production.

2.3 Feed Cost Risk Reduction

Points on price risk management via forward contracting or hedging were obtained from a number of papers that were published as part of the National Program for Integrated Dairy Risk Management Education & Research (2000). This was a joint effort sponsored by a number of land grant universities and private organizations to help those in the dairy industry, including producers, understand and manage a number of risks including those associated with input and output market price volatility. In the first series of papers, Benson (2000) explains why dairy producers should be interested in price risk management for an understanding of risk and how controlling certain risks will help maintain the success of the operation. Proper risk management includes three main elements. First is being able to comprehend the sources of risk and being able to identify the impact of specific risks. Second is the need to prioritize the various risks in terms of likelihood and severity. Finally is to understand and implement risk management strategies and decision-making tools.

Benson (2000) indicates that the market risk for a dairy producer is the possibility of higher feed prices, falling milk values, or some combination thereof. There are many factors that influence feed and milk prices including weather, inventories of key products, changing technology, and government policies. Producers should have at least some idea of how these factors impact values and to what extent. With regard to prioritizing risk, the dairy producers should ask themselves what is the chance or probability that an adverse event will occur and if so, how severe will be the impact. If the probability of an unfavorable event is low and the impact should it occur is estimated to be slight then no action is required. On the other hand, should the probability of an adverse event stay low but the impact catastrophic, some action is needed. If the probability of an adverse event is high but its impact slight, then action may be necessary, but only if it is deemed effective. Finally, if the probability of an adverse event is high and the impact is severe then immediate action is required. All of this depends on the degree of risk aversion of the individual producer. In the case of a dairy producer, looking at input and output prices specifically, at what levels do prices have to rise or fall before the combination of reduced revenues and higher input costs puts a severe crimp in the operation. For instance, how would an operator react if corn, one of the main constituents in today's dairy rations, moves from $120 per ton to $150 or even $200 per ton? What about the possibility of milk falling to $10.00 per hundredweight or even $8.00. The producers must ask themselves what is the probability that milk prices would fall to such low levels, how long will such depressed values persist, and how long the operation can survive these low prices. Finally, with regard to understanding risk management strategies and decision making tools, the manager has to decide that if the probability of an adverse event is high and its impact, should it occur, is likely to be severe then some sort of action is necessary to minimize its impact. When talking about price risk management, Benson (2000) says that producers are shifting the risk to others via hedging and forward contracts. Such decisions require time to plan out a strategy, implement the chosen strategy, and monitor and review how the implementation of risk management strategies affected the bottom line. For instance, if a dairy producer engaged in a forward contract for a certain feed ingredient or bought some put options on milk futures, what was the final price for feed or milk relative to what they would have paid or received were no action taken? In actuality, producers need to continually engage in forward contracting if opportunities present themselves. This is the only way to gauge their effectiveness. There are often cases of dairy producers either engaging in forward contracting just once and if the results are poor they often sour on the experience and never attempt to use such strategies again.

Bernhardt (2000) discusses the topics of risk and uncertainty, the management responses required by each, and the tools available to cope with these concepts. An event is when something happens or occurs. An outcome is the result or consequence of an event. A probability is the likelihood that some specific outcome will occur. The value at risk is the amount lost should the negative event occur. For a dairy producer an event could be described as when milk prices fall and the outcome may be a decline from $13.00 per hundredweight to $10.00 per hundredweight. The probability that such an outcome will occur, a $3.00 per hundredweight decline in milk prices may perhaps be calculated as 10% while the value at risk is the amount of milk produced in hundredweights times $3.00 per cwt. Uncertainty is defined as when you do not know all of the outcomes, the probability of the outcomes is unknown, or both the probability and the outcomes are unknown. Berhardt (2000) describes risk as a situation where all the possible outcomes are known and though one does not know which outcome will occur, the probability associated with each outcome is known. For dairy producers, there are a number of uncertain and risky events that could transpire and a manager has to know how to respond to each. With risky events, it is possible to quantify to some extent the probability that an adverse output could occur though there is no way of knowing if it will actually occur. Still, in the case of production or price risk, a variety of risk management tools such as insurance, forward contracts, or hedging instruments could be employed to help offset the impact an adverse event would have should it occur.

Volatility of prices, on both the input and output sides were examined by Thraen and McNew (2000). The lowering of the government support program prices along with the reduced Federal stockpiles of dairy products such as cheese and butter have made milk values much more volatile over the past 15 years. Similar legislation has impacted feed prices with the USDA enacting policies that resulted in a dramatic shrinking of the government stockpiles of grain that had accumulated over the years. The disappearance of these buffer stocks has resulted in prices of many key feed commodities becoming much more volatile. Thraen and McNew note how feed commodity prices have become increasingly responsive to changes in supply-demand fundamentals with weather perhaps the great influencing factor. In recent years, other factors such as crude oil prices and their impact on the production of ethanol have also exerted great influence on feed values. During the study period of this paper, 1999-2004, the production of various renewable fuels did not have the market impact as seen today.

Though there are still some market stabilization and price enhancing provisions in U.S. government farm programs, it is expected that both milk and feed prices will remain quite variable for years. Thraen and McNew (2000) write that today's dairy producer will have to adopt strategies to help better manage these market price risks. They suggest that dairy producers should develop a "zone of expectations" with regard to both feed and milk prices. One possibility is to obtain the average price of milk or a particular feed ingredient over a period of time and also the standard deviation. Then for either milk or feed, if prices are distributed normally, a price range that would be expected to occur 68% of the time for different periods of the year could be derived by taking the average and adding and subtracting one standard deviation. Seasonal variability is important to monitor since both milk and feed prices exhibit seasonal characteristics. Feed values tend to be lowest in the fall, coinciding with the U.S. row crop harvest while milk prices are highest at this time of year based on falling production due to the cumulative effects of the summer heat and increased demand for fluid milk as schools re-open. Another supportive seasonal factor for milk prices is retailers starting to accumulate cheese and butter inventories for the upcoming year-end holiday season. On the other hand, milk prices are lowest in the spring as production supply is high due to good seasonal forage conditions and the closing of schools, which reduces fluid milk demand. Meanwhile, feed prices are at their highest levels of the year, linked to uncertainty about crop production prospects for the upcoming growing season, and a reduced supply of product from the fall harvest. With a zone of expectation and an understanding of the seasonal variability, a dairy producer at least has some sort of framework to make a determination as to whether a spot or forward feed or milk value is too high or too low.

Having developed some sort of formalized process to determine when feed and milk prices are at attractive levels, dairy producers can then take steps to lock them in. McNew (2000) reflects on how feed prices have become more volatile over the years based on increased globalization of the world grain and oilseed markets and the decline in government stocks. Monitoring feed costs is very important as they represent at least 50-60% of total costs. The values of many feed ingredients to varying degrees are driven by the corn and soybean meal futures prices determined by trading at the Chicago Board of Trade. The author makes note of the variety of ways a dairy producer can buy feed. Most common is a cash contract from a local supplier on either a spot or forward basis. Producers can also store feed on farm and for many California dairies, a year's worth of forage is often stored. Then there are more complicated contracts; especially those tied to the Chicago Board of Trade. These include basis contracts, hedging with futures, and options on futures. The most common and the one used in this analysis is a cash forward contract which is a legal document for a specified quantity of feed at a pre-determined price for a specific time in the future. The contract can be for feed next week, all of next month, or for the next year. The advantages of these contracts are a known price and quantity, no transactional costs, and the fact that the feed is tailored to the producers needs with regard to quantity and price. However, these contracts may lock a producer into what eventually results in high prices or more feed than required.

2.4 Milk Price Risk Reduction

Stephenson (2000) discusses milk price volatility. It is a bulky product in fluid form that is perishable and difficult and costly to transport. In order to help minimize price fluctuations and provide dairy producers with some sort of safety net provision, there was an extensive dairy price support system enacted at the Federal level. Though these programs did help stabilize milk prices for milk production to some extent, they often resulted in large government purchases of cheese, butter, and dried milk products that proved costly to maintain. Furthermore, starting in the 1980's, legislators began to orient farm policy more towards a free market basis as burgeoning Federal budget deficits led to major revamping of the Federal subsidy programs for a number of commodities as enacted in more recent Farm Bills. There was also a desire to align dairy programs more toward the General Agreement on Tariffs and Trade (GATT) and the World Trade Organization (WTO). These are the former and present international bodies, respectively, that deal with trade in both goods and services.

Cropp (2000) reviews how to manage output price risk. The tools, cash forward contracts, futures, and options are similar but here the adverse event is falling prices as opposed to the risk of high prices on the feed side. Hedging is the concept of taking a position in the futures market that is opposite one's position in the cash market. A dairy producer is long milk in the cash market. Everyday milk is produced, now and in the future, the risk is that milk prices may fall. By selling futures, a milk producer can lock in a price for delivery in the future and help offset the chance that the actual cash milk price received at some point forward in time will be lower than it is today. Similar to what is seen on the feed side, before entering a forward contract, either cash or futures, the operators should have an idea of whether that forward price is favorable or not. Often cited as perhaps the biggest disadvantage for cash forwarding feed or milk is the fact that a producer is locked into the contract so if feed prices fall below the contract price or milk prices rise above the contract there is no recourse. To help bridge the gap, there are put options on milk futures that give producers the right, but not the obligation to sell a specified quantity of milk at a specified price within a fixed period of time. This allows a producer to set a price floor for a portion of their milk produced while allowing them to capitalize on higher milk prices should that happen. Similarly, dairy producer can also use call options on corn and soybean meal futures to lock in a portion of their feed needs while allowing them to benefit from lower feed prices should they materialize.

CHAPTER III: MILK PRODUCTION BACKGROUND INFORMATION

3.1 Overview

Since the early 1990's, milk prices have become more volatile with prices swinging wildly between record highs and record lows. Behind this phenomenon has been the move by the Federal government to gradually lower the price support mechanisms for milk. This was in response to high levels of milk production that occurred in the 1970's and 1980's, far above market clearing levels that contributed to ballooning Federal stockpiles of butter, cheese, and other manufactured dairy products. Demand for milk is generally thought to be price inelastic meaning that small surpluses or deficits in production can cause wide swings in prices. Figure 3.1 illustrates how the Federal support price, currently at $9.90 per hundredweight often acts as a floor on values. The Basic Formula Price (BFP) is now known as the Class III milk contract and is the most widely used proxy for a general milk value. The USDA manages this support program by purchasing a variety of dairy products; primarily cheese, butter, and non-fat dry milk when values fall below certain mandated levels. Since January 1, 1999 the USDA has supported milk prices at the $9.90 per hundredweight level with the butter purchase price at $1.05/lb., block cheese purchased at $1.13/lb., barrel cheese purchased at $1.10/lb. and non fat dry milk purchased at $0.80/lb. The depletion of dairy product stocks from Commodity Credit Corporation warehouses as depicted in Figure 3.2 has resulted in milk prices becoming more dependent on market forces. Milk for the most part is a non-storable commodity so a little bit extra or less than the market demands can cause wide variability in prices received. Figure 3.3 shows how the reduced government support price has narrowed the spread between national milk production and the commercial disappearance of milk on a milkfat and milk equivalent basis. Commercial disappearance is the most common figure used to approximate total milk and dairy demand in the U.S.

The cycle begins when prices are high and dairy producers have an optimistic view of the future. In addition to earning high levels of income and adding equity toward the business, expansion plans are put in motion. This involves new capitalization for herd enlargement, the construction of new facilities, and the purchase of new inputs. Farmers also pre-pay feed expenses to reduce their tax burden and then also pay taxes on remaining farm profits. The increased herd expansion leads to greater milk production linked to higher cow numbers and the increase in per cow productivity that has characterized the industry over the past years. Since 1960, average milk production per cow in the U.S. has increased 2.4% annually. At this point milk production is increasing faster than demand so milk prices plummet. This process propagates a cash flow problem, as producers cannot cover both fixed and variable expenses. This results in producers falling behind on debt repayments for capital requirements already purchased and crimps farm income received, which adversely affects the family living situation. The transmission effect continues as the producer reduces cash expenditures including those for feed and other input purchases. This results in a cheaper ration being fed along with foregoing some of the higher priced feed inputs that accentuate milk flow and component levels. This eventually leads to a loss in milk production which combined with lower milk values exacerbates the situation. The net result is the producer taking on new short-term debt to allow them to cash flow for the year but this also results in lost equity for their farm business. Eventually the cumulative effects of the lost milk production results in demand exceeding available supplies necessitating a rise in milk prices and hence the cycle starts again.

Given this price cycle behavior and the volatility in milk prices as depicted in Figure 3.1, one would assume that milk producers would be willing to take steps to eliminate or at least reduce part of the price risks they face in both feed inputs and milk. Generally speaking, this has not been the case even though volatility, at least on the milk side, has increased over the past few years. BFP-Class III milk prices were examined over 24 years, from 1981 to 2004, and by three eight-year periods, 1981-1988, 1989-1996, and 1997-2004. BFP is the Basic Formula Price which replaced the old Minnesota-Wisconsin price series in June of 1995 and is considered the bellwether milk price for most of the U.S. The BFP and Class III are essentially synonymous as the price of milk. Table 3.1 indicates that average annual milk prices were higher for 1997 to 2004 than they were in the previous eight-year period. For instance during the 1981 to 1988 time period the average was $11.86 but the average increased to $12.07 from 1989 to 1996, and then to $12.34 from 1997 to 2004. There is a trade-off however, as milk prices have become far more volatile in the recent time period than in the past as measured by the standard deviation and coefficient of variation. For the eight-year period, 1997 to 2004 the coefficient of variation in BFP price was 20.36 which was double the prior eight-year period and triple that from the 1981-1988 period. The eight-year period, 1997 to 2004 experienced both the highest and lowest annual average prices over the past 24 years, resulting in a greater range of values than existed before. Ironically, this variability in milk price helps explain one of the reasons why producers are not more active in price risk management, at least on the output side. Many operators have seen record high prices over the past few years, most recently $15.39 in 2004. They know that when they forward contract via the futures market or through a cash contracts they are locking in a specific price and foregoing the opportunity for higher prices should they materialize.

An integral first step is for a producer to know the costs of production and from there the break-even price of milk can be ascertained. A simple equation for farm profits could be established.

(3.1) Net Return ($/cwt) = ((milk price ($/cwt) – feed costs ($/cwt)) * milk volume (cwt) - other variable costs ($/cwt) – fixed costs ($/cwt).

Milk prices and feed costs are generally thought to be the most volatile parts of the equation. Figure 3.4 shows that feed costs for west coast operations can vary considerably, moving from $7.50 per hundredweight of milk to less than $6.00/cwt. Since this study period was completed, feed costs per hundredweight of milk have become even more variable and prohibitively expensive. Feed costs for most California dairy operations account for over 75% of total variable costs and close to half of total operating costs. On the revenue side, receipts for milk sold are far in excess of income earned from cattle sold. Producers need a milk price that will pay all expenses, contribute to debt reduction and capital replacements, and to realize enough dollars for family living expenses.

3.2 Variability of Feed and Milk Prices

There are certain seasonal and cyclical factors that influence both milk production and prices. Weather, spring flush, and number of fresh cows are some of these factors. Milk marketing is spread out continuously. California dairies get a check each month so y definition they do get the average price of the year. To enhance milk revenues, the key is to eliminate or at least moderate the impact of low prices. Producers may do this with cash contracts with processors, fixed price contracts, basis contracts, and long-term agreements

Feed prices are highly variable and influenced by such factors as weather, government policies, or changes in basis. Another consideration is the purchase of feed as opposed to farm raised feed. With feed being the single greatest cost to a dairy operation, both in terms of operating and variable costs as depicted in (Figure 3.4), producers must be vigilant in monitoring the value of all feed ingredients. Operators have a number of options in order to gain greater certainty as to how much they will be paying for key ingredients including cash forward contracts or using grain and oilseed futures and option contracts to help hedge against adverse price movements. Variability in both feed and milk prices is one of the greatest sources of risk to a dairy operator. Comprehending and managing these variable price risks is essential for today's operators.

3.3 Milk-Feed Ratio

To help understand the concepts of price variability and risk, we examine a measure that is commonly used to assess profitability in the dairy industry which is the milk-to-feed ratio. The Milk-Feed Ratio is defined as the number of pounds of a 16% crude protein mixed dairy feed that can be purchased from the revenues received from selling one pound of the All Milk Price at its current value. The mixed dairy feed mixture for the ratio calculation consists of 51 pounds of corn, 8 pounds of soybeans, and 41 pounds of alfalfa hay. The corn, alfalfa, soybean, and All Milk Values are U.S. averages as reported by the USDA's NASS division in their monthly Agricultural Prices series. A dairy producer would not actually feed this mixed dairy feed but rather it is a representation of the energy (corn), protein (soybeans), and fiber (alfalfa) components of a standard dairy ration. A combination of higher milk prices and/or lower feed costs will increase the value of the milk-feed ratio while conversely lower milk and/or higher feed costs will decrease its value. It is commonly thought that a milk-feed ratio at 3.00 or higher indicates a generally profitable dairy industry with conditions ripe for expansion.

Figure 3.5 shows that the milk-feed Ratio has averaged 2.86 since 1990 with a standard deviation of 0.47 meaning that approximately two-thirds of the time the milk-feed ratio has been within a 2.39 to 3.33 range assuming it is normally distributed. During the period 1999-2001, the dairy industry was quite profitable as many operations, especially in the western U.S. expanded to an unprecedented degree. While the milk-feed ratio uses spot values, it is possible utilizing a combination of derivative and forward contracts of milk and feed to set favorable milk-feed ratios well into the future. This is important since the milk-feed ratios appear to have become more variable over the past few years, specifically from the period 2000-2004. Figure 3.6 illustrates the monthly Milk-Feed Ratio along with a rolling five-year average of both the Milk-Feed Ratio and the coefficient of variation, which is the standard deviation of the Milk Feed Ratio divided by the Milk-Feed Ratio average. The period from 1998-2004 saw higher milk feed ratios than from 1992-1998 but that was accompanied by increased volatility in this index as measured by the rising coefficient of variation figures.

Though variability in the milk feed ratio has increased in recent years, is it due to more volatile feed or milk prices, or a combination of both? The Figure 3.6 shows the rolling five-year coefficient of variation (CV) for the milk feed ratio and for each of its components, the All Milk Price, and values of corn, alfalfa, and soybeans for 1995 through 2004. Corn had the highest volatility over the period as measured by the CV. It averaged

18.45, followed by soybeans with an average of 15.33. Interestingly, the All Milk Price had the lowest coefficient of variation of all the series averaging 10.09 over the ten-year period. This suggests that producers may want to initially focus their price risk management strategies on the feed as opposed to milk. Results furnished later in this paper indeed show the highest returns are achieved by forward contracting feed and accepting the monthly spot milk price.

Dairy producers face many uncertainties including not knowing what the future price of milk and feed inputs will be. Probability is the chance associated with a particular outcome. Price risk exists if there is a chance of more than one price outcome. There is risk in ascertaining what milk prices may be six months forward though each possible outcome (a specific price observation) has a probability of occurring. A summary of the probability of all outcomes is referred to as a probability distribution. A probability distribution is the range of possible outcomes with their associated chances of occurring. This can also be converted into a cumulative probability function. We do not know what will occur in the future but analysis of past price history is often used to make forward forecasts. As an example, Figure 3.7 illustrates the monthly Federal Basic Formula Price from January 1994 to December 2004. Also included is the 132-month average, which in this case is \$12.36/cwt and lines representing plus and minus one standard deviation of \$2.32/cwt. In this eleven-year period, two-thirds of the time the BFP or now the Class III annual price average ranged from \$10.13/cwt to \$14.39/cwt. There is a school of thought that if one is forecasting future price direction based on past price history, the more recent time periods should be weighted more heavily, especially if it is believed that conditions for the coming months or years will be more like the recent years as opposed to more distant years in the past.

Figure 3.7 also includes a trend-line that shows milk values have had a small positive trend over the past decade. However, when the exceptionally strong 2004 values are removed, prices trended slightly lower from 1994 to 2003. Using a weighted-average system starting with the price as of December 2004 and assigning it a weight of 132, November 2004 a weight of 131, and continuing until January 1994 with a weight of 1, this weighted average price comes out to $12.45, about nine cents higher than the simple average. Figure 3.8 which graphs the Class III milk prices and its 12-month moving average in $/cwt shows prices in the latter half of the 10-year period from 1994 to 2003 were lower than 1994-1998 values. On November 2001, the BFP or Class III value fell below the 12-month moving average and stayed below that average until June 2003, a period of 19 months, which is the longest such period of what one would call "depressed values" in the whole time period. Over the ensuing 18 months, values were above the 12-month rolling average so it appears that the high and low price time periods are lasting longer than in the past. Although the simple and weighted averages along with the plus and minus standard deviation lines are based on past history, a California dairy producer might expect the milk price they receive to average between $12.36 to $12.45 with two-thirds of the time falling between $10.13 and $14.39. For comparative purposes, for the most recent 10-year period, January 2000 to December 2009, the Class III average was $13.28/cwt and values were in a range from $10.05/cwt to $16.52/cwt two-thirds of the time.

Another way to examine expected values is to look at all the observations, which in this case is the monthly BFP-Class III price from January 1994 to December 2004. Figure

3.9 puts all of these observations into a cumulative probability distribution. From January 1994 to December 2004, 50% of the time the BFP-Class III price was $12.05/cwt or less. Conversely, in that time period, the BFP-Class III price averaged $12.94/cwt or more slightly less than 33% of the time. This cumulative probability distribution can provide producers who make future pricing decisions based on past price data a more realistic set of expectations. For instance, a producer may desire a price of $14 for their milk yet only 22% of the time from Jan 1994 to December 2004 did this or a higher value occur. While forming a range of price expectations for future values based on past price history is a very useful exercise, it is important to consider whether past milk price action will be a reliable guide to future price activity. Revised state and federal milk pricing policies, technological changes impacting dairy production, and shifts in consumer consumption patterns of key dairy products are but some of the factors that could influence future milk values.

Many agricultural commodities exhibit a high degree of price seasonality. Milk prices have a seasonal pattern depending on the time of year. Milk output tends to peak in the spring when weather conditions are generally the most favorable, additional fresh (having just birthed) cows coming into production, and the first and second hay cuttings providing better forage. This period of enhanced output is known as the "spring flush". Concomitant with these increased supplies is a drop in demand for fluid milk consumption as schools are closing for the summer. Conversely, milk production tends to decline in the fall as the cumulative effects of the more stressful summer conditions along with a general decline in forage quality reduces cow productivity. At the same time, enhanced demand for milk in all forms occurs with students returning to schools and upcoming November and December holiday festivities occurring that lead to greater utilization of cheese and butter.

Thus milk prices follow a seasonal pattern of being lower in the spring and higher in the fall. Figure 3.10 graphs the seasonality of milk prices incorporating the monthly Class III milk price from the years 1980 to 2004. Values are highest in the September-October time frame with the peak being close to 6% over the annual average. The low period occurs in March-April at about 6% below the annual average.

Knowing ones' costs of production and having an idea of what the expected range of future milk prices may be, a dairy producer can then utilize some of the risk management tools to help manage price variability. Using either exchange traded instruments such as futures or options, cash forward contracts, or perhaps some custom made derivative or some combination thereof, producers can either lock in a fixed or put a floor on future milk prices. The Class III milk futures contract traded at the Chicago Mercantile Exchange can be used to price milk going forward. For most dairy producers in the U.S., the milk price they receive is based on the Federal Milk Marketing Order system. There are four classes in the Federal system with Class I used for fluid milk, Class II is milk used for soft cheeses, Class III is milk used for hard cheeses, and Class IV is for milk manufactured for butter and powder. For most regions, the Class III is weighted more heavily since more milk is utilized for hard cheeses than any other purpose. For the state of California, dairy producers are paid what is known as the Overbase price, which is a combination of the 4a and 4b price. The California 4a price is based on milk paid by butter/powder plants and is very similar to the Federal Class IV price while the California 4b price is based on milk sold to hard cheese plants and is thus similar to the Federal Class III contract. Figure 3.11 shows both the Class III Basic Formula Price and the California

Overbase, the relation between these two prices is very close with a correlation coefficient of 90.3% over the entire time series and an even tighter 94.5% since January 2000.

Using this information, milk producers can forward contract part or all of their milk production using futures and options or some combination thereof. The number of producers who utilize exchange traded options and futures is quite small. Another alternative is for a producer to sign a cash contract with the processor or creamery they ship to. These cash forward contracts offer the producer a specified price for future milk production to be delivered to the buyer's milk plant. Though the use of cash forward contracts is greater than exchange traded contracts, the number of producers who engage in cash forward contracting is also limited. Mengel et al.(2002) noted that in its simplest form, a forward contract between a milk buyer and a milk producer (or cooperative) is an agreement to sell a stated quantity of milk, for a stated period into the future, at a stated price. A forward contract is a type of risk management instrument that has potential benefits to both parties. Producers and handlers are able to “lock in” prices, thereby reduce risk associated with price and income volatility and enhance their ability to obtain new or continued financing. A forward price contract is a tool that can be used alone or in conjunction with other pricing tools to manage price risk.

Offered prices can change daily, while the terms of the contracts may be available for individual months, six months, or even a year. Most cash forward contracts are for a guaranteed base price related to the Class III milk futures contract price. Producers are still eligible for the same premiums and discounts (for milk composition and quality) as are producers who do not forward contract. Some milk plants offer a type of cash forward contract called a floor price contract. Dairy producers are given Class III put options to set a floor for the milk price. If the milk price rises, they get more than the floor price. If the milk price falls below the floor, they get the floor price. Any option premiums and transactional fees are taken out of the final milk check the plant sends to the producer. A major advantage of cash forward contracts is their flexibility. While futures contracts and options require relatively large fixed quantities of milk (200,000 pounds for a Chicago Mercantile Exchange Class III milk futures contract), cash forward contracts can be for much smaller quantities - as little as 10,000 pounds of milk per month though for some California dairies 200,000 pounds can represent a day's worth of milk production. Another advantage of cash forward contracts is that they are simple to use. You just ask the milk buyer what contract price is being offered forestalling the need to establish an account with a licensed broker and maintain a margin account as you would if you used exchange traded options and futures.

Disadvantages of cash forward contracts include the fact that producers are normally not allowed to get out of the contract. That means being locked into delivering milk to the buyer they contracted with. It also means foregoing opportunities to take advantage of rising milk prices (unless it is a floor price contract). There is also production risk since producers are not only contracting for a specified price but also a specified quantity. Should excess heat or disease lower production from what had been planned, producers are still responsible for delivering that quantity of milk contracted for. This is usually not too much of problem since it is recommended that producers lock in no more than 50-60% of expected future production. The main advantage of using exchange traded options to forward contract milk is their flexibility. Using these contracts, if for some reason it is decided that there is no longer need to forward contract, one can easily exit from the contract by either buying back the short futures position or selling back your long put option. The disadvantage is that these contracts require 200,000 pound increments. There are also transaction fees.

Table 3.1: Summary Statistics of Milk Prices ($/cwt), 1981-2004.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1981-2004													
Mean	11.91	11.51	11.61	11.86	11.90	11.95	12.17	12.47	12.78	12.54	12.21	12.17	12.09
S.D	1.41	1.05	1.21	1.95	2.17	1.80	1.56	1.65	1.66	1.42	1.75	1.88	1.63
High	16.27	13.32	14.49	19.66	20.58	17.68	15.46	15.79	16.26	16.04	16.84	17.34	16.64
Low	9.78	9.54	9.11	9.41	9.37	9.46	9.33	9.54	9.92	10.02	8.57	9.37	9.45
Range	6.49	3.78	5.38	10.25	11.21	8.22	6.13	6.25	6.34	6.02	8.27	7.97	7.19
C.V.	11.80	9.14	10.40	16.41	18.26	15.07	12.84	13.26	12.97	11.35	14.31	15.42	13.44
1981-1988													
Mean	12.00	11.86	11.77	11.70	11.68	11.65	11.68	11.79	11.95	12.05	12.13	12.03	11.86
S.D	0.69	0.78	0.84	0.86	0.85	0.85	0.80	0.68	0.61	0.59	0.59	0.60	0.73
High	12.64	12.66	12.67	12.64	12.61	12.59	12.53	12.48	12.64	12.64	12.72	12.62	12.62
Low	10.91	10.60	10.43	10.33	10.34	10.34	10.52	10.98	11.12	11.21	11.19	11.12	10.76
Range	1.73	2.06	2.24	2.31	2.27	2.25	2.01	1.50	1.52	1.43	1.53	1.50	1.86
C.V.	5.73	6.61	7.10	7.32	7.29	7.30	6.87	5.79	5.13	4.86	4.86	4.97	6.15
1989-1996													
Mean	11.89	11.53	11.55	11.79	11.89	12.03	12.16	12.37	12.67	12.55	12.29	12.09	12.07
S.D	1.16	0.88	0.96	1.04	1.13	1.12	1.24	1.23	1.16	1.12	1.27	1.42	1.15
High	13.94	12.59	12.77	13.09	13.78	13.91	14.49	14.97	15.37	14.13	14.69	14.93	14.06
Low	10.16	10.04	10.02	10.04	10.23	10.58	10.99	11.17	11.90	10.48	10.25	10.19	10.50
Range	3.78	2.55	2.75	3.05	3.55	3.33	3.50	3.80	3.47	3.65	4.44	4.74	3.55
C.V.	9.80	7.65	8.29	8.84	9.47	9.35	10.19	9.93	9.14	8.96	10.36	11.76	9.48
1997-2004													
Mean	11.85	11.13	11.52	12.08	12.14	12.16	12.66	13.24	13.72	13.03	12.21	12.40	12.34
S.D	2.16	1.39	1.77	3.25	3.66	2.91	2.30	2.41	2.35	2.12	2.84	3.02	2.51
High	16.27	13.32	14.49	19.66	20.58	17.68	15.46	15.79	16.26	16.04	16.84	17.34	16.64
Low	9.78	9.54	9.11	9.41	9.37	9.46	9.33	9.54	9.92	10.02	8.57	9.37	9.45
Range	6.49	3.78	5.38	10.25	11.21	8.22	6.13	6.25	6.34	6.02	8.27	7.97	7.19
C.V.	18.20	12.51	15.37	26.86	30.15	23.98	18.17	18.19	17.10	16.27	23.23	24.34	20.36

Figure 3.1: Basic Milk Price vs. Federal Support Level.

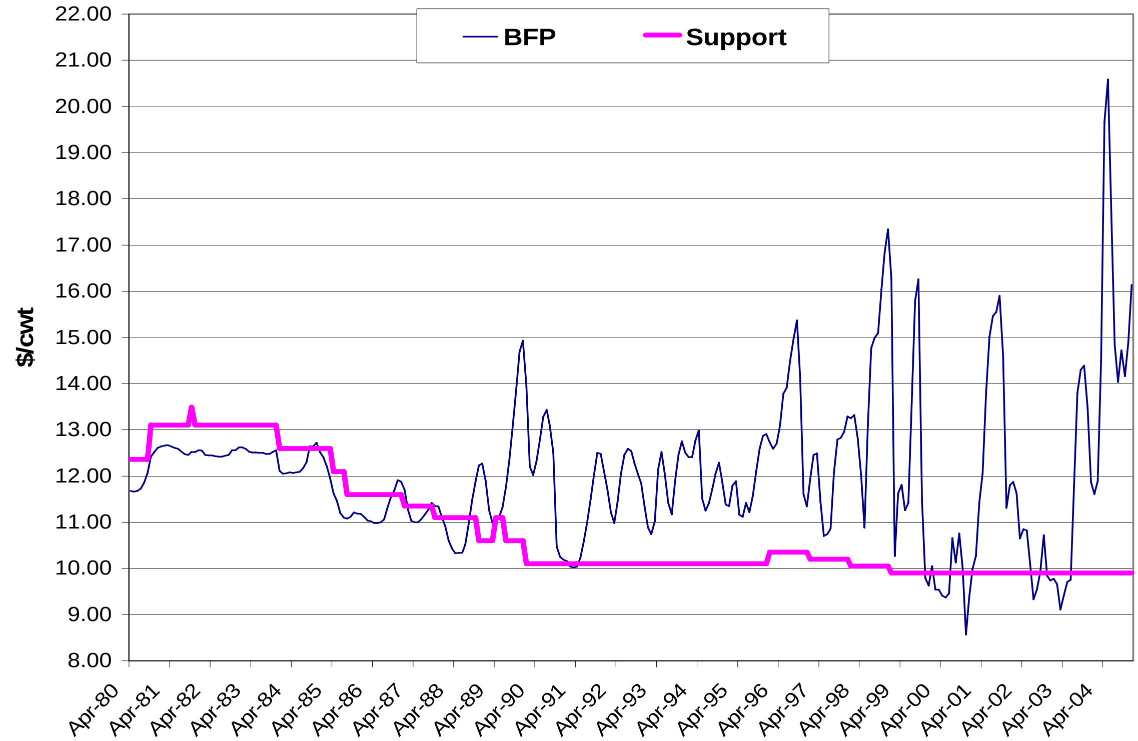


Figure 3.2: Government Holdings of Dairy Stocks, Milk Equivalent & Milkfat

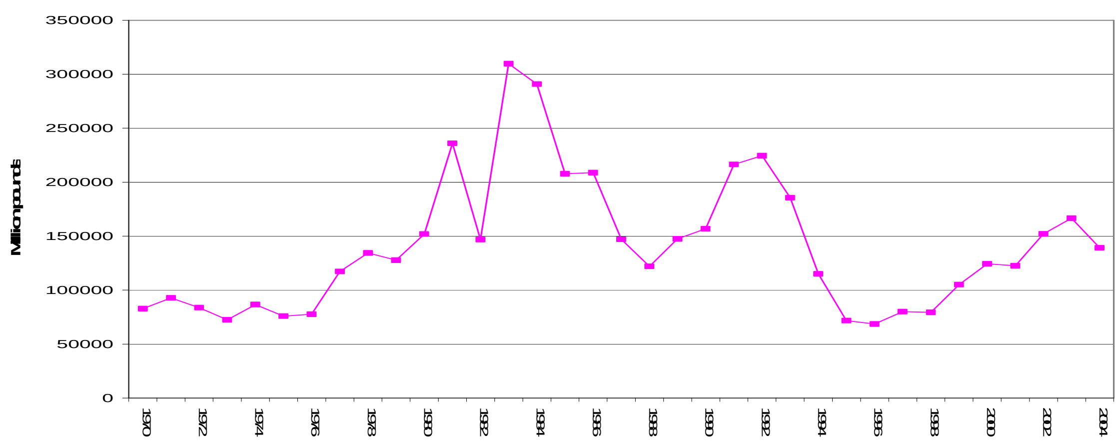


Figure 3.3: U.S. Milk Production vs. Commercial Disappearance of Milk

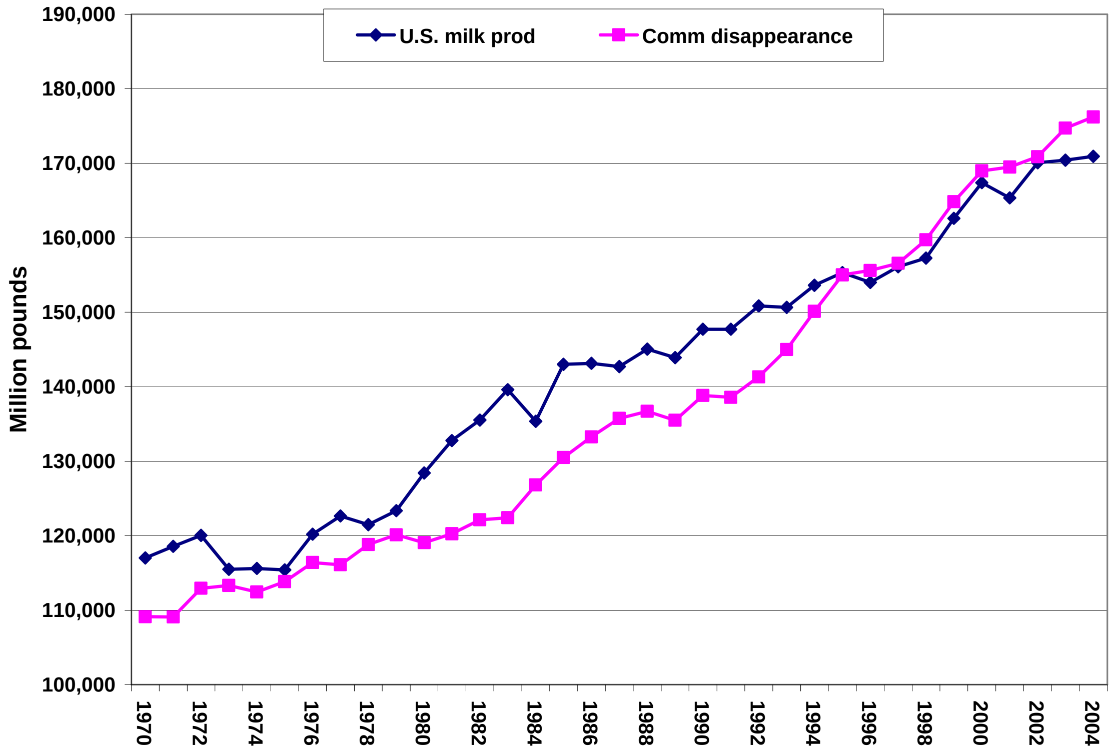


Figure 3.4: CA Dairy Feed Costs as % of Operating and Total Costs

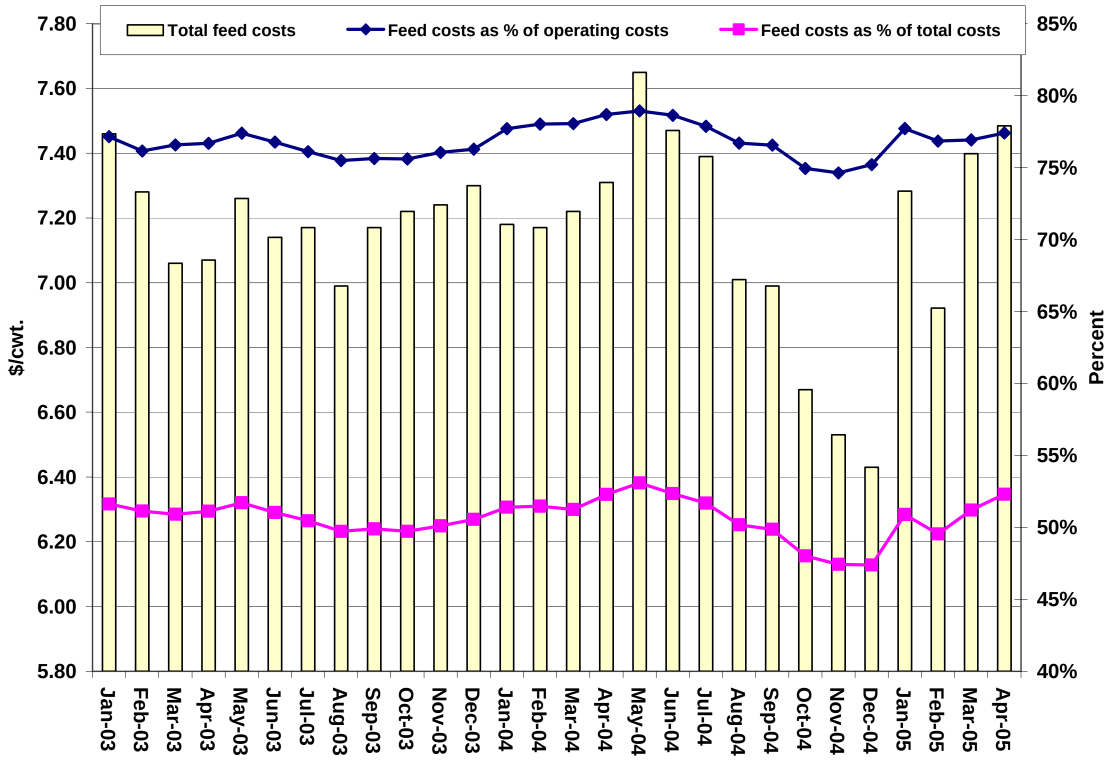


Figure 3.5: Monthly Milk-Feed Ratio with Rolling 5-Year Average and CV

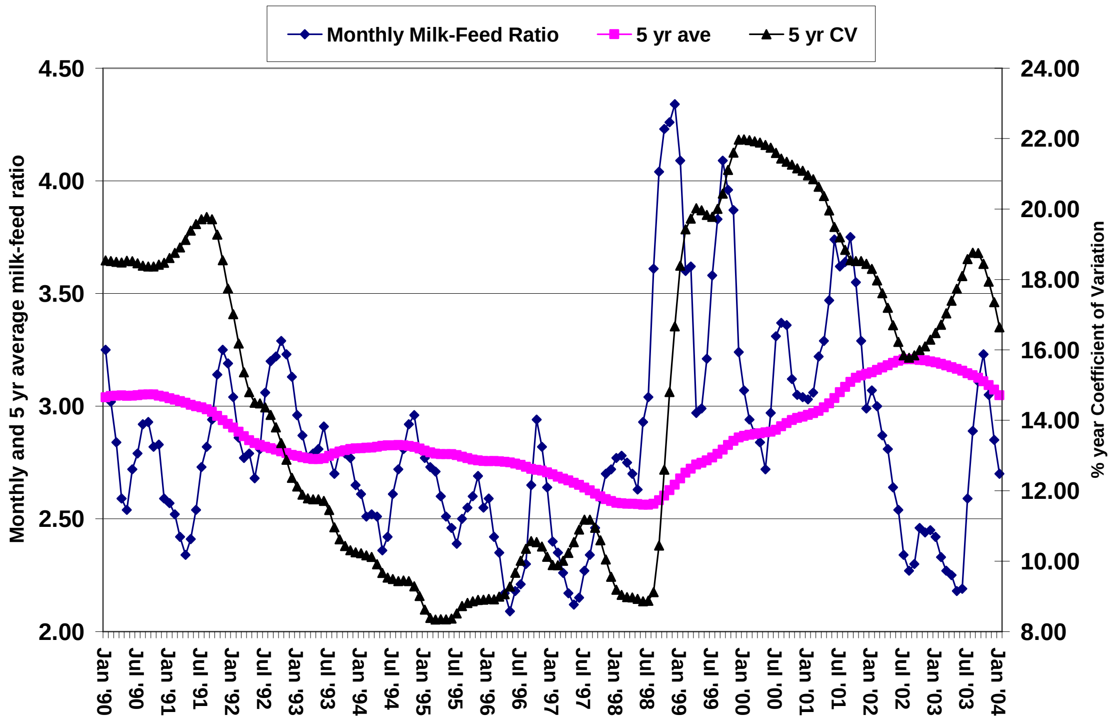


Figure 3.6: Rolling 5-Year Coefficient of Variation Figures for Milk-Feed Components

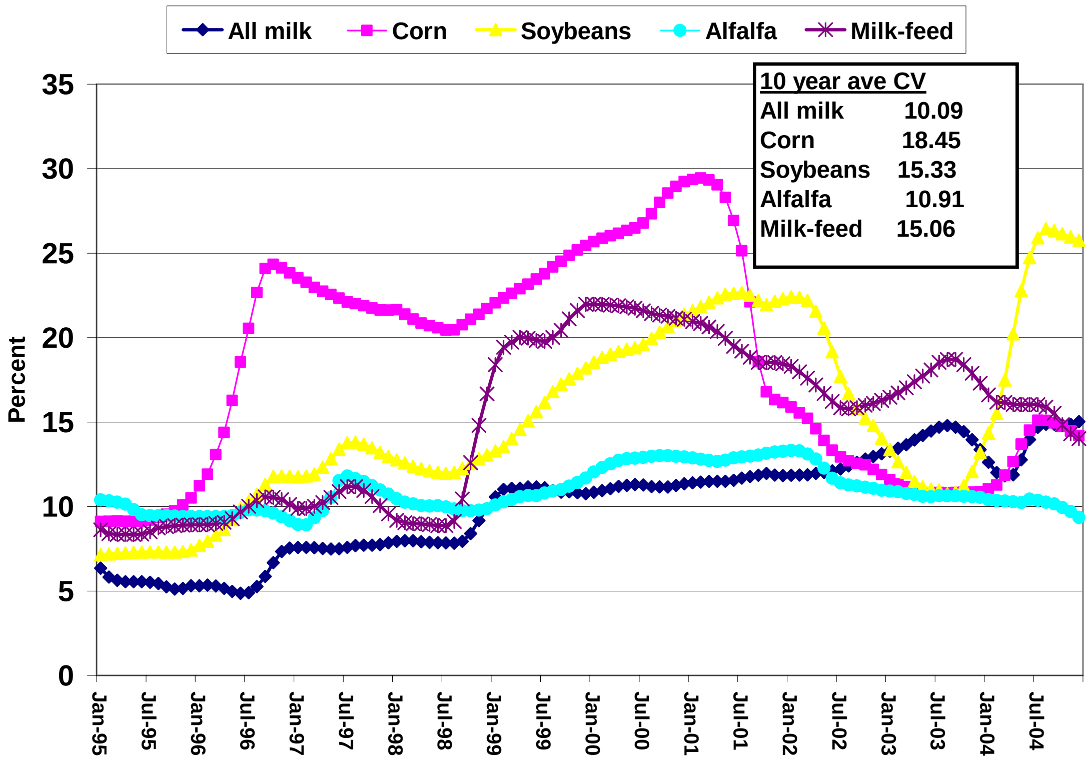


Figure 3.7: Monthly Class III Values with Average, Trend, and Plus and Minus One Standard Deviation

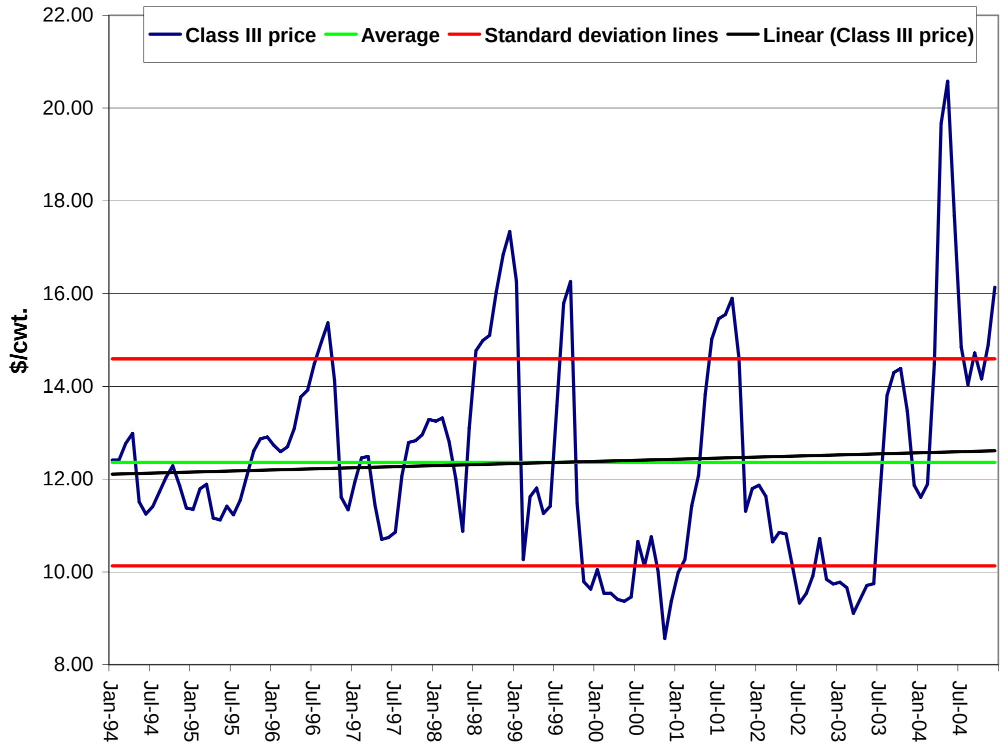


Figure 3.8: Class III Milk in $/cwt. and 12-Month Rolling Average

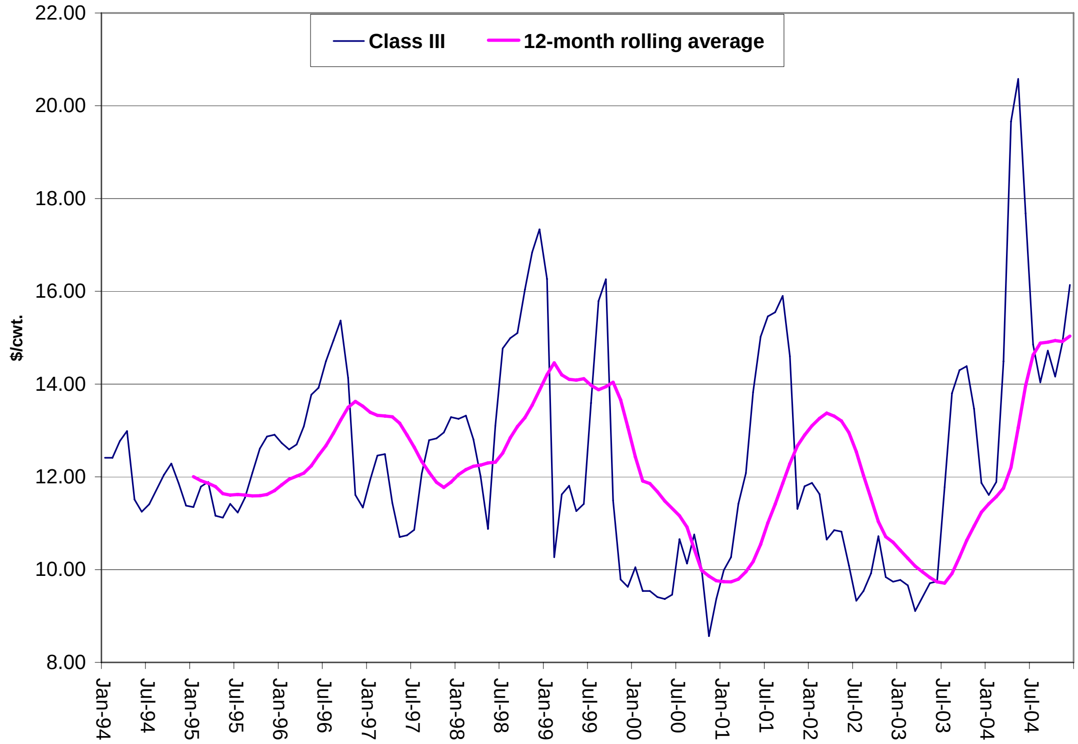


Figure 3.9: Cumulative Probability Distribution of Class III Milk Prices, Jan 1994-Dec 2004

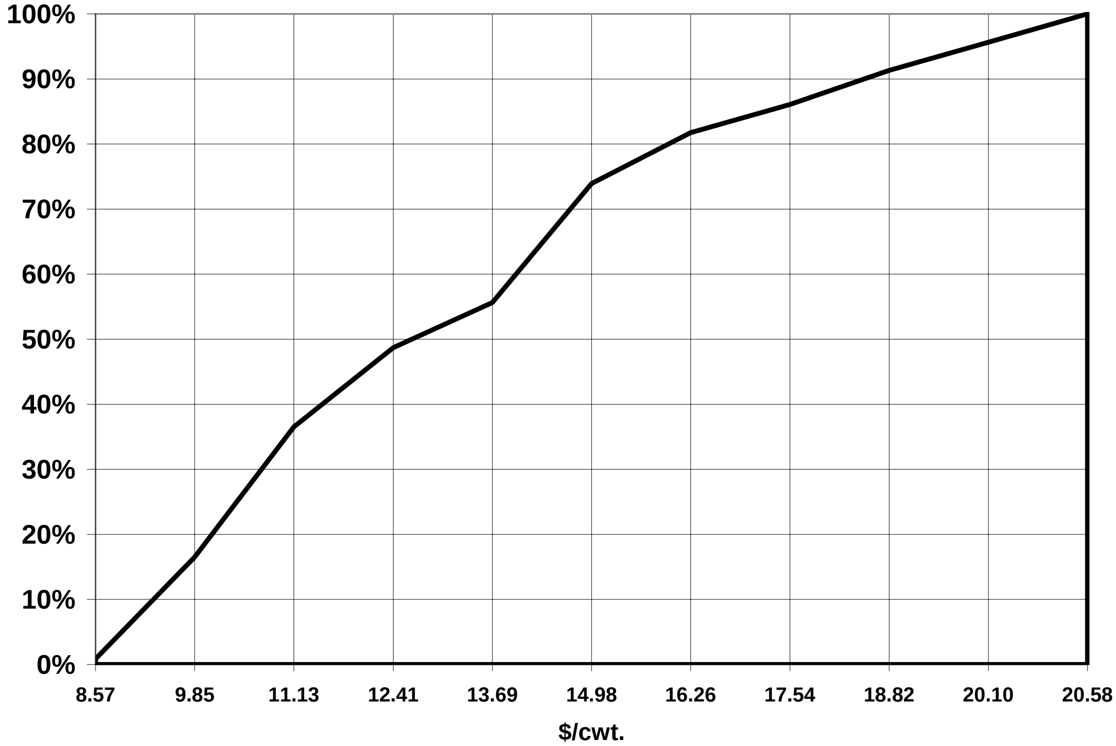


Figure 3.10: Seasonality of Class III Milk Prices in $/cwt. 1980-2004

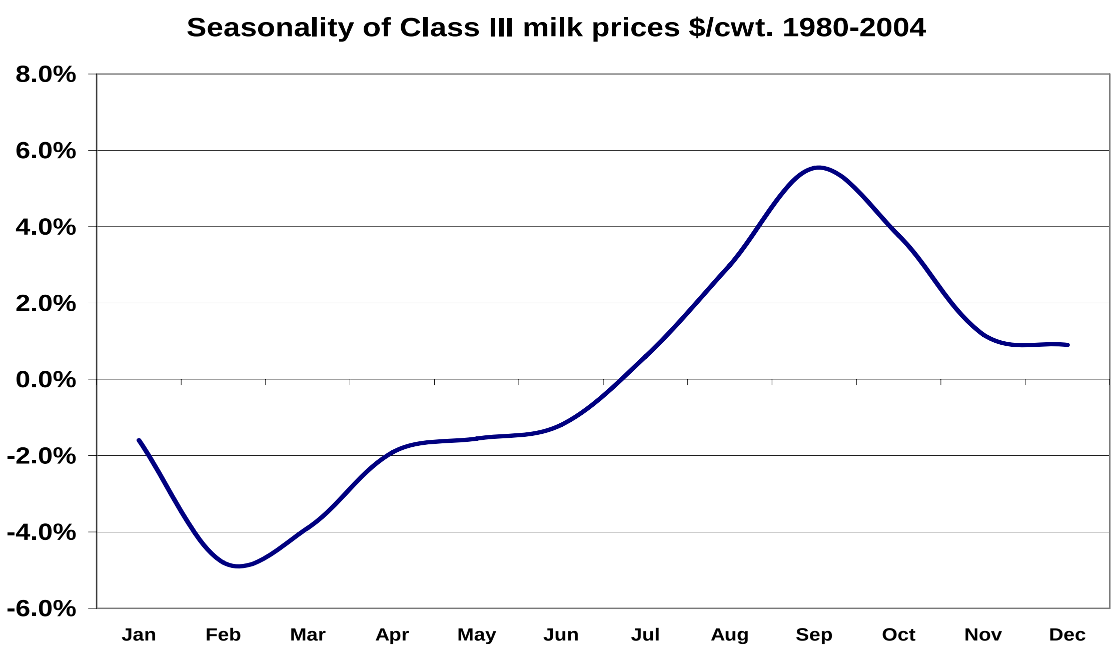
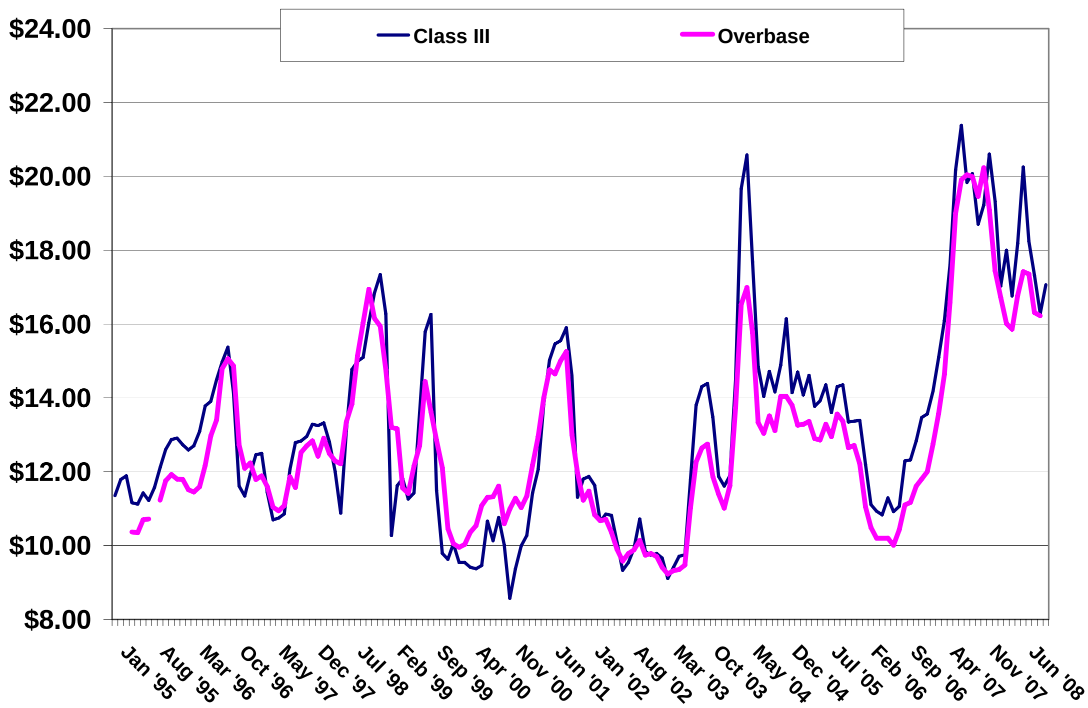


Figure 3.11: California Overbase vs. U.S. Class III Milk Price



CHAPTER IV: PROCEDURES AND DATA

4.1 Overview of Procedures

A model was developed that could use either a least-cost or profit-maximization method to formulate a dairy feed ration. What follows is an explanation of the ration model and the procedure that was used to develop the net energy-milk production function. An explanation of how the nutritional requirements were developed and how the feed ingredient values were calculated is also provided. The reasons for the milk pricing scenarios are also explained.

4.2 Elements of Optimization

Formulating a feed ration is a classic example of mathematical programming. Mathematical programming is used to find the optimal or most efficient way of using limited resources to achieve an objective while either maximizing profits or minimizing costs. Two ration formulation models were developed. One uses the least-cost method which minimizes feed costs. The other is a profit-maximization model that maximizes net returns, which is equal to milk revenues minus feed costs. These types of ration formulations are known as optimization models and are characterized by one or more decisions that have to be made and constraints on the alternatives faced by the decision makers.

Optimization models are expressed mathematically with the various decision variables denoted by the symbols X_1, X_2, ...,X_n. The decisions variables represent the quantity of each feed ingredient that is chosen for a particular ration. Constraints are often expressed as some function of the decision variable that must be less than, greater than, or equal to some specific value which is signified as the letter b. Examples of constraints are;

a less than or equal to constraint: $f(X_1, X_2, ...,X_n) \leq b$

a greater than or equal to constraint: $f(X_1, X_2, ...,X_n) \geq b$

an equal to constraint: $f(X_1, X_2, ...,X_n) = b$

The objective in an optimization problem is represented mathematically by an objective function in the general format: MAX (or MIN): $f(X_1, X_2, ...,X_n)$. The objective function identifies some function of the decision variables that the decision maker wants to either MAXimize or MINimize. The mathematical formulation of an optimization problem can then be described in the general format:

MAX (or MIN): $f_0(X_1, X_2, ...,X_n)$,

subject to: $f_1(X_1, X_2, ...,X_n) \leq b_1$,

$f_k(X_1, X_2, ...,X_n) \geq b_k$, and

$f_m(X_1, X_2, ...,X_n) = b_m$,

This representation identifies the objective function, MAX (or MIN): $f_0(X_1, X_2, ...,X_n)$ that will be maximized or minimized and the constraints that must be satisfied. The goal of optimization is to find the values of the decision variables that maximize or minimize the objective function without violating any of the constraints.

The general form of the least-cost or minimization model is as follows;

<u>Feed Ingredient Cost Minimization Model</u>

Min Feed Cost = $\Sigma\, a_i\, j_i$

where:

Feed Cost	=	$\Sigma\, a_i\, j_i$
a_i	=	Amount of i^{th} feed ingredient fed, i = 1 to 16
j_i	=	i^{th} feed ingredient price, i = 1 to 16

subject to:

			Table 4.1 Columns
NEL/day	$\geq$	NEL/day requirement	AE $\geq$ I
CP/day	=	Crude protein requirement	AF = J
DMI/day	$\geq$	Dry matter intake requirement	AG $\geq$ H
lbs. alfalfa/day	$\geq$	.40 × Dry matter intake/day	AK $\geq$ .40 × AG
lbs. almond hulls/day	$\leq$	.25 × Dry matter intake/day	AL $\leq$ .25 × AG
lbs. fat/day	$\leq$	03 × Dry matter intake/day	AT $\leq$ .03 × AG
lbs. hominy/day	$\leq$	.25 × Dry matter intake/day	AU $\leq$ .25 × AG
lbs. molasses/day	$\leq$	.03 × Dry matter intake/day	AV $\leq$ .03 × AG

The general form of the profit-max or maximization model is as follows;

Profit Max Model

Max NR = Milk Revenue – Feed Cost

where:

Milk Revenue	=	lbs./day of milk production × Price of Milk Received
Feed Cost	=	$\Sigma\, a_i\, j_i$
a_i	=	Amount of i^{th} feed ingredient fed, i = 1 to 16
j_i	=	i^{th} feed ingredient price, i = 1 to 16

subject to:

			Table 4.1 Columns
NEL/day	$\geq$	NEL/day requirement	AE $\geq$ I
CP/day	=	Crude protein requirement	AF = J
DMI/day	$\geq$	Dry matter intake requirement	AG $\geq$ H
lbs. alfalfa/day	$\geq$	.40 × Dry matter intake/day	AK $\geq$ .40 × AG
lbs. almond hulls/day	$\leq$	.25 × Dry matter intake/day	AL $\leq$ .25 × AG
lbs. fat/day	$\leq$	03 × Dry matter intake/day	AT $\leq$ .03 × AG
lbs. hominy/day	$\leq$	.25 × Dry matter intake/day	AU $\leq$ .25 × AG
lbs. molasses/day	$\leq$	.03 × Dry matter intake/day	AV $\leq$ .03 × AG

The decision variables and constraints for both the least-cost and profit-maximization models are essentially the same. NEL is net energy for lactation and the sum total of NEL contained in each of the chosen feed ingredients should be equal to or greater than the NEL requirement for a cow of a given weight and specified level of milk production as specified in the National Research Council (2001). CP is crude protein and the sum total of CP contained in each of the chosen feed ingredients should be equal to the CP requirement for a cow of a given weight and specified level of milk production as specified by the NRC (2001). DMI is dry matter intake of all feed adjusted to a 100% dry matter basis. The sum total of DMI contained in each of the chosen feed ingredients should be equal to or greater than the DMI requirement for a cow of a given weight and specified level of milk production as specified in the NRC (2001).

When formulating a dairy ration, some discretion may have to be used with the quantities of the various feed ingredients that the computer has chosen depending upon how well the model represents actual production conditions. This may be due to the fact that the biological realities of the cow may not tolerate too much of a certain feed, some feeds may not react well synergistically, and some ingredients may be unpalatable, or too wet. The ration model developed has the constraints previously described. These are mostly limited to minimum amounts of net energy and crude protein needed to support a specified level of milk production but some additional constraints were established. For proper digestion, cows need a certain amount of forage in their diets to stimulate rumination which helps keep the rumen stable. For that reason alfalfa hay needs to comprise at least 40% of the Dry Matter Intake (DMI). Almonds hulls are a uniquely California feed ingredient that have a large amount of digestible fiber and energy. Although it is an excellent feed, it is a fibrous material so large quantities can lead to increased rumen fill limiting the amount of other, more energy dense ingredients that need to be included in the ration. For that reason, it is limited to no more than 25% of the derived DMI. Fat is often added to dairy rations since it is a concentrated source of energy and helps reduce the dustiness of the feed pile. Excess intake, can however lead to a variety of feeding disorders and inhibits the action of the fiber digesting microbes. For that reason the inclusion rate is limited to no more than 3% of the derived DMI. Hominy is a by-product of the corn flour milling industry and is a close substitute for corn in the ration. It is an excellent source of energy yet it contains a high amount of fat and for that reason the inclusion rate is limited to no more than 25% of the DMI. Finally the inclusion rate for molasses is limited to no more than 3% of the DMI. Molasses is a form of sugar and has a high energy value. It is rapidly fermented in the rumen and that can lead to a variety of feeding disorders so amounts fed are usually small.

The difference between the two models is that the least-cost method will formulate a ration that meets the nutritional requirements of a lactating cow at the lowest possible cost for a given level of milk production. The profit-maximization model incorporates into its algorithm the production function between net energy intake and milk production so it will formulate a ration using both feed and milk prices. Here the cost of the last unit of feed provided is equal to the revenues of the last unit of milk produced allowing the difference between milk revenue and feed cost to be maximized. A final point is there are two reasons why the NEL and DMI constraints are specified as being greater to or equal to the NRC specifications yet the crude protein is just equal to the NRC recommendations. In the profit-maximization model, the higher milk production generated results in levels of NEL and DMI needed that are well in excess of NRC recommendations. Secondly is that increased net energy intake drives milk production, not higher levels of crude protein consumed. It has been documented that higher crude protein consumption is of no benefit to the cow, is costly to the owner, and high levels of crude protein intake can be environmentally degrading.

4.3 Forward Contracting

In this paper, the impact of forward contracting both feed and milk on the returns of a typical California dairy producer in terms of income over feed costs on a daily basis is studied. For feed costs, the models have 16 commonly fed ingredients, 11 of which had a sufficient price history to select a forward pricing criteria.

In the models used in this thesis that use forward contracting the criteria for contracting inputs is as follows. Unless the forward contracted price for a feed input is below the five-year average price of that ingredient minus one-half a standard deviation, the current spot price for that particular feed ingredient is used rather than a contract price. A second objective is to lock in a low forward price for an extended period of time if possible. This is based on the mentality that a producer would want to lock that "low" price in for as long as possible.

Data from the Class III milk futures contract traded at the Chicago Mercantile Exchange was used to forward contract milk. The criteria for deciding to contract milk prices was the rolling five-year average plus one standard deviation using either strips of futures or individual months. If offered a good high priced forward contracting opportunity, that price was locked in for as long as possible. A review of the data shows that while using the five-year average plus one standard deviation allows for a number of forward contracting opportunities for milk, this is not the case for most of the 11 feed ingredients that could be forward contracted. A rolling five-year average less one-half a standard deviation was used for the criteria for forward contracting feed ingredients. The-264 week study covering the period August 1999 through August 2004 did allow sufficient length of time to gauge the impact of forward contracting for both milk price series and nine out of the fifteen feed ingredients.

It is only based on past price history that the forward contracted value is considered favorable. It may turn out that spot feed prices are lower than the forward contracted values or spot milk prices turn out to be higher than the forward contracted numbers. This is one area of study. Another is to compare results over the 264-week period in terms of average daily milk production, net energy intake per day, crude protein intake per day, dry matter intake per day, milk revenue per day, feed cost per day, and finally profit per day. While recognizing that average net returns are very important, part of the reason that some operators forward contract both milk and/or feed is to reduce the variability in net returns. So while forward contracting milk or feed may actually result in less favorable prices than if one were to rely on the spot markets, the reduced volatility in prices may be a desired goal. The coefficient of variation figures for average daily milk production, net energy intake per day, crude protein intake per day, dry matter intake per day, milk revenue per day, feed cost per day, and profit per day are compared for all 12 chosen strategies. Finally, the net returns of the least-cost method versus those of the profit-maximization method are examined. The profit-maximization model will choose that mix of feed ingredients that maximizes the difference between the daily feed cost and the daily milk revenue. The price of milk is an integral part of this procedure. The more commonly employed least-cost method will formulate a ration for a given level of milk production based strictly on feed costs.

4.4 The Gestation-Lactation Cycle

Figure 4.1 illustrates the typical milk production, dry matter intake, body condition score, milk fat percent, and milk protein percent curves over a period of time. The curves in Figure 4.2 are the standard daily milk production, dry matter intake, and bodyweight changes measured in pounds that occur over a typical lactation cycle. These curves were calculated from the data presented in Figure 4.1 Hutjens (2003). The values for the daily milk production, dry matter intake, body weight changes, and milkfat percentage used in this study were approximated from these curves. These curves quantify the daily changes for milk production, fat percentage, bodyweight, and dry matter intake seen for a "typical" cow as she goes through her 305-day lactation cycle. Once a cow gives birth she starts producing milk. The volume gradually increases, peaking around the tenth week of lactation and today's modern cows can produce up to and over 100 pounds of milk per day. In order to supply this milk, the cow has to eat more and its dry matter intake does start to increase. Still, the cow cannot eat enough to provide the necessary energy needs for high milk production so body reserves are utilized and the cow does lose weight. After milk production peaks it starts to decline at a gradual rate though dry matter intake does continue to increase. This results in the cow gaining weight. Similarly, the cow's milkfat percentage starts out at a high level and then declines in concert with rising milk production. At peak daily milk output, the fat percentage of the milk usually hits its low point and then starts to increase as milk production starts to decline and the animal starts to increase in weight. Typically, a cow gets pregnant 60 days after calving and as she proceeds through the lactation period the amount of milk she gives will decline as more nutrients are directed toward the growing calf and away from milk production. The final part of the cycle is known as the dry period which occurs 30-60 days before the cow gives birth. At this point the cow is managed in such a way as to stop milk production and direct all nutrients consumed to the growing calf. This cycle is then repeated and most California dairy cows will go through this cycle three or four times.

4.5 Ration Formulation Spreadsheet Model Description

The ration model consists of six spreadsheet pages. The first page with the tab ***Profix max model*** consists of columns from A to AZ and 264 rows that correspond to the six consecutive 44-week lactation cycles. The second page presents the calculations for the 44-week lactation cycle. The third page is the solver or linear program that incorporates the optimization algorithm. The fourth page includes the spot feed values, the fifth page contains the forward feed values, and the sixth page has the three series of milk prices, spot, and the two forward contract values, the Strips Months Model (SMM) and the Individual Months Model (IMM).

The following is a description of the ration section of the model which is displayed in Table 4.1. Note that throughout Table 4.1, prices are listed just for the first 44 of the 264 weeks.

Column A – This is the week of the lactation cycle. There are 44 weeks per cycle, weeks 1-44. This is repeated 6 times for 264 weeks or 1848 days ≈ 62 months ≈ 5 years.

Column B – Week. This is the actual week of the lactation cycle. The feed and milk values used are the actual values that occurred that week using either spot or forward contracted values. Since formulations were calculated on a weekly basis months are denoted as having either four or five weeks. As an example Aug 99-5 is the fifth week in August of 1999 while Oct 02-2 is the second week in October of 2002. The study period extends from the first week August 1999 to the last week of August 2004. January, May, August, and October were the months designated to have five weeks with the other eight months having four weeks.

Column C- Body Weight. This is the body weight (lbs.) of the cow during each week of lactation as depicted in Figure 4.2.

<u>Column D</u>- Milk. Average milk production (lbs./day) in each week of lactation. These are standard milk production changes that occur over a typical lactation cycle as depicted in Figure 4.2.

<u>Column E</u>- Milk Fat %. These are standard milkfat percentage changes that occur over a typical lactation cycle as depicted in Figure 4.1.

<u>Column F</u>- 3.5% Fat Corrected Milk. This is the standard industry accepted formula for calculating pounds of 3.5% fat corrected milk per day using the pounds of milk per day and the percent of milkfat for that amount of milk produced Linn et al.(2004).

*Milk 3.5% corrected (lbs/day) = (Milk production lbs/day * 0.4324) +* **(4.1)**

*(Milk Fat %/100 * Milk Production lbs/day * 16.216)*

<u>Column G</u>- 4.0% Fat Corrected Milk. This is the standard industry accepted formula for calculating pounds of 4.0% fat corrected milk per day using the pounds of milk per day and the percent of milkfat for that amount of milk produced Linn et al.(2004)..

*Milk 4.0% corrected (lbs/day) = (Milk production lbs/day * 0.4) +* **(4.2)**

*(Milk Fat %/100 * Milk Production lbs/day * 15)*

<u>Column H</u>- Dry Matter Intake Constraint. This is lbs of 100% dry matter intake required per cow per day. This information is from Table 4.2 and is based on the maximum value in each period for three different DMI estimates found in columns F, G, and H in Table 4.2.

<u>Column I</u>- This is the Net Energy for Lactation constraint or NEL (Mcal/day) required for the cow. This comes from Table 4.3, the net energy for lactation calculations sheet. The NRC (2001) lists recommended guidelines for a cows NEL and crude protein as a function of bodyweight and the pounds of fat corrected milk. Because the bodyweight values for a cow in the model range from 1310 pounds to 1450 pounds depending on the week of lactation, the cows daily maintenance NEL requirement is calculated using the following (Hutjens, 2003)

*NEL maintenance requirement = (Bodyweight (lbs)-1300)*0.005+9.6.* (4.3)

Each pound of milk with a milkfat of 3.0% requires 0.29 Mcal of NEL, 3.5% requires 0.31Mcal, 4.0% requires 0.33 Mcal, 4.5% requires 0.35 Mcal, and 5.0% requires 0.37 Mcal. Since the milkfat percent values for the cows in the model range from 3.3% to 4.1% depending on the week of lactation, the NEL needed per pound of milk for the milkfat percent is calculated using the following (Hutjens, 2003).

*NEL (Mcal) lb milk =(milkfat percent-3.0%)*0.04+0.29).* (4.4)

The total daily NEL requirement in column N (Table 4.2) for both maintenance and daily milk production is a combination of the two previous equations 4.3 and 4.4 and is calculated using the following (Hutjens, 2003).

*Total daily NEL requirement =((Bodyweight (lbs)-1300)*0.005+9.6)+((milkfat percent - 3.0%)*0.04+0.29)*lbs milk per day* (4.5)

An example of the use of equation 4.5 follows. In the fifth week of lactation in the first 44 week period, which is Aug 99-5, the cow had a bodyweight (BW) of 1370 lbs, produced 79.2 lbs. of milk at a milkfat percent of 3.70%. Entering this information in equation 4.5 results in the following

Total daily NEL requirement = ((1370-1300) * 0.005 + 9.6) + ((3.7% - 3.0%) * 0.04 + 0.29) * 79.2 = 35.14 Mcal NEL/day. Table 4.3, the Net Energy for Lactation sheet lists the NEL associated with various bodyweight and milk fat percentages. For the example above, a cow with a BW of 1370 has a maintenance NEL value of 9.950 and the NEL for a milkfat percent of 3.7% is 0.318 Mcal/lb. Multiplying 0.318 by 79.2 lbs of milk per day and adding the maintenance requirement of 9.950 Mcal yields a total NEL requirement of 35.14 Mcal/day.

<u>Column J</u>- Daily Crude Protein Constraint in lbs/cow/day. These values are in Table 4.4, and can be found in the crude protein calculations sheet. The NRC lists recommended guidelines for a cows NEL and crude protein as a function of bodyweight and the pounds of fat corrected milk. Because the bodyweight values for the cow in this model range from 1310 pounds to 1450 pounds depending on the week of lactation, the cows daily CP requirement is calculated using the following (Hutjens, 2003)

*Crude protein maintenance requirement = (BW-1300)*0.0004+0.89.* (4.6)

Each pound of milk with a milkfat % of 3.0% requires 0.078 lbs of CP, 3.5% milkfat requires 0.084 lbs CP, 4.0 % milkfat requires 0.090 lbs CP, 4.5% milkfat requires 0.096 lbs CP, and 5.0% milkfat requires 0.102 lbs CP. Because the milkfat percent values for the cows in the model range from 3.3% to 4.1% depending on the week of lactation, the crude protein needed per pound of milk for the milkfat percent is calculated using the following (Hutjens, 2003)

.

*Crude protein/ lb milk =(milkfat percent-3.0%)*0.012+0.078).* (4.7)

Therefore the total daily CP requirement for both maintenance and daily milk production is a combination of the two previous equations 4.6 and 4.7 and is calculated using the following (Hutjens, 2003)

*Total daily crude protein (CP) requirement = ((BW-1300)*0.0004+0.89) + ((milkfat percent -3.0%)*0.12+0.078)*lbs milk per day* (4.8)

An example of the use of equation 4.8 follows. In the fifth week of lactation in the first 44 week period which is Aug 99-5, the cow had a bodyweight of 1370 lbs, produced 79.2 lbs. of milk at a milkfat percent of 3.7%. Entering these data into equation 4.8, the total daily CP requirement = ((1370-1300) * 0.0004 + 0.89) + ((3.7% - 3.0%) * 0.12 + 0.078) * 79.2 = 7.76 lbs CP/day. Table 4.4, the Crude Protein calculations sheet, lists the CP associated with various bodyweight and milk fat percentages. For the example above, a cow with a BW of 1370 has a maintenance CP value of 0.918 lbs and the CP for a milkfat percent of 3.7% is 0.0864 lbs/lb of milk. Multiplying 0.0.0864 by 79.2 lbs of milk per day plus the maintenance requirement of 0.918 lbs yields a total CP requirement of 7.76 lbs/day.

Column K- Milk Price ($/cwt). Milk prices are from the milk forward contracting sheet (Table 4.6). The milk price could either be the cash or BFP value or one of the two forward contracting models depending upon which strategy is being examined. One strategy used strips of futures (Strips Months Model or SMM), and the other that used the individual futures months (Individual Months Model or IMM). If either the SMM or IMM values exceeded the price needed to meet the criteria for forwarding contract then those values were used otherwise the actual cash BFP- Class III price was utilized. The price needed was the Class III rolling five year average plus one standard deviation. An explanation on how the forward milk prices were derived is provided later.

Column L- Predicted Milk Production in lbs/day. Predicted milk production is from Equation 4.9. Values in columns A and B of Table 4.7 were extrapolated using the high production curve in Figure 4.3 (Dean et al. 1972). Values shaded in grey were used to generate a logarithmic curve that represented a milk production function for a high producing cow. This function is plotted in Figure 4.4 using estimated values from the high production curve

. *Milk production lbs/day 3.5% FCM = 50.085 Ln (NEL Mcal/day) – 102.99* (4.9)

The predicted net energy function which is used in equation 4.9 assuming 3.5% fat corrected milk is calculated with equation 4.10

*Predicted NEL (Mcal/day) = EXP (0.0198 * lbs of 3.5% FCM)* (4.10)

Source: Dean at al. 1972

<u>Column M</u> – Column M is the label for rows 2 through 6 of the nutrient value for each of the 16 ingredients that compose the feed library. These are from the NRC (2001) and are listed in Table 4.8, row 2 through 5 along with the percent of dry matter (DM%) for each pound of that specific feed ingredient. For each feed ingredient listed in columns N through AC. For each ingredient the net energy for lactation (NEL) is in Mcal per pound of feed, the crude protein (CP) is expressed in pounds per pound of feed, the grams of Calcium (Ca) per pound of feed, and the grams of Phosphorus (P) per pound of feed where all feeds are on a 100% dry matter basis.

<u>Columns N – AC</u> - Nutrient Values and Feed Ingredient Prices. These columns contain two items. Rows 3 through 6 contain the nutritional values for each of the sixteen ingredients. Rows 7 and higher contain the prices of the feed ingredients. Feed ingredients values are taken from a variety of sources. These include the daily price sheets published by the California Grain and Feed Association, hay prices from the USDA's Agricultural Marketing Services division, and spot and forward values of common feed ingredients obtained via the daily price sheets published by a number of California feed companies that are publically disseminated. Feed ingredient prices ($/lb) for spot values are listed in Table

4.9 and forward values are listed in Table 4.10. The number 1 is entered in Table 4.1 when there is no spot or forward price for a particular ingredient. This translates into a price of $2,000 per ton, too high a price for the ration formulator to consider in all cases. Various sets of prices are entered in this section depending upon the strategy examined for each of the 264 weeks.

Column AD - Milk Produced. Milk production per day using equation 4.9 calculated. Milk production is equal to pounds of 3.5% fat corrected milk based on the milk production formula.

Column AE - Net Energy for Lactation (NEL). The total NEL (Mcal/day) needed to support a level of milk production is calculated in Column AE. The model generates this NEL number which will be greater than or equal to the NEL constraint in column I in Table 4.1. This NEL figure is the sum of the energy from all feed ingredients chosen and the quantity selected by the optimization as indicated in columns AK through AZ in Table 4.1.

Column AF- Total Daily Crude Protein (CP) is the lbs/day needed to support a specific level of milk production. The model generates this value to meet the crude protein constraint in column J of Table 4.1. This figure is the sum of the crude protein of all feed ingredients chosen and the quantity selected by the optimization as indicated in columns AK through AZ in Table 4.1.

Column AG- Total Daily Dry Matter Intake (DMI). This is the lbs/day needed to support a specific level of milk production. The model generates this value to meet the dry matter constraint in column H of Table 4.1. This figure is the sum of the dry matter of all feed ingredients chosen by the optimization as indicated in columns AK through AZ in Table 4.1.

<u>Column AH</u>- Total Milk Revenues. Milk revenues ($/day) are the pounds milk produced times the milk price. It is the product of the milk values ($/lb) in column K of Table 4.1 times the milk production (lbs) in column AD in Table 4.1

<u>Column AI</u>- Total Feed Cost. This cost ($/day) is the product of the feed values ($/lb) in columns N-AC of Table 4.1 times the feed costs (lbs/day) for the various ingredients chosen in columns AK-AZ of Table 4.1

<u>Column AJ</u>- Daily Profit. This net return is the milk revenue ($/day) minus feed costs ($/day). This equals the value in column AH minus the value in column AI, of Table 4.1.

<u>Columns AK – AZ</u> –The level of each feed ingredient in the optimal feed ingredient mix (lbs/day) for each week is reported in these columns in Table 4.1. These are the quantities of each ingredient chosen by the ration formulation model.

Data and underlying calculations to support the milk production function and optimization model are reported in tables 4.2 to 4.8.

- Table 4.2 contains the 305-day lactation statistics. Of note here are the three different DMI calculations. Column F is daily DMI in pounds per day based strictly as a function of bodyweight. Column G of Table 4.2 is another measure of DMI that is a function of bodyweight and the pounds of 4% fat corrected milk. The final DMI calculation in column H of Table 4.2 incorporates the latest NRC formula for dry matter intake that is a function of bodyweight and pounds of 4% fat corrected milk. It is also adjusted by week of lactation with a lag factor to account for reduced intake early in the cycle. These values are listed in column I of Table 4.2. In the profit-max formulation ration model, the largest of the three DMI values were used allowing the maximum of each value per week. Column J in Table 4.2 includes the DMI values used in column H of Table 4.1.

- Table 4.3 contains the net energy for lactation (NEL) calculations. Values shaded in yellow are from Table 4.5, the NRC nutrient requirements sheet. The NRC (2001) maintenance NEL requirement for a cow with a bodyweight (BW) of 1300 lbs is 9.60 Mcal/ per day, for a 1400 lb cow is 10.10 Mcal/day, and for a 1500 lb cow is 10.60 Mcal. These are listed under the maintenance of a mature lactating cow section in Table 4.5. Similar with the milkfat percentages in column 4 in Table 4.3, those values are also taken from Table 4.5, the NRC nutrient requirements sheet spreadsheet under milk production-nutrients per pound of milk of different fat percentages.
- Table 4.4 contains the crude protein calculations. Values shaded in yellow are from Table 4.5 column 2, the NRC nutrient requirements sheet. The NRC maintenance crude protein (CP) requirement for a cow with a bodyweight (BW) of 1300 lbs is 0.89 lb/day, for a 1400 lb cow is 0.93 lb/day, and for a 1500 lb cow 0.97 lb/day. The values for crude protein requirements based on different milkfat percentages are shaded in yellow from Table 4.5 column 2.
- Table 4.5 contains the National Research Council (NRC) nutrient requirements for dairy cows. Tables 4.3 and 4.4 list respectively the NEL and Crude Protein requirements for dairy cows based on their bodyweight and amount milkfat adjusted milk production.
- Table 4.6 contains the milk contracting prices. These include the spot or BFP price, the Strips Months Model (SMM) price and the Individual Months Model (IMM) price.

- Table 4.7 contains the milk production function calculation sheet. These values were extrapolated from the high production curve (Dean et al 1972) that is reproduced on page 80 of this thesis.
- Table 4.8 contains the nutrient specifications of all 16 feed ingredients contained in the feed ingredient library. Values include the net energy for lactation (NEL), crude protein (CP), calcium (Ca), phosphorus (P), and the dry matter percent for each of these ingredients.

4.6 Solver

The actual optimization model as described in section 4.2 is presented in Table 4.11. The program optimizes the feed ingredient mix each week of the 264-period studied (Table 4.1). The target column is either column AI (total feed cost) or column AJ (profit), both in Table 4.1. If column AI is chosen then the least cost model is solved. Based on the price of the various feed ingredients, the program will choose a ration for a pre-set level of milk production at the least possible cost. This level of milk production is based on the amount of net energy for lactation (NEL) that is in column I of Table 4.1. If column AJ is chosen, the profit-maximization model is solved. Based on the price of the various feed ingredients, the program will choose a ration for a level of milk production that will maximize the difference between milk revenues and feed costs.

4.7 Feed Input Prices

There are 16 different ingredients in the feed library used in both the least-cost and profit-maximization models. They are alfalfa hay, almond hulls, barley, beet pulp, canola meal, corn, whole cottonseed, cottonseed meal, dried distillers grain, fat, hominy, molasses, rice bran, soybean meal, soyhull pellets, and wheat middlings. For four of those ingredients, alfalfa hay, beet pulp, fat, and rice bran there was little or no forward contract information so spot values were used for both the least-cost and profit-maximization models.

For the other 12 ingredients, there is a possibility of forward contracting. The criteria for forward contracting a particular ingredient was if the offered forward price is less than the five-year rolling average minus half of a standard deviation. With the model starting August of 1999 in order to have at least a five-year history to compute the moving average and standard deviation calculations, feed price values were needed going back to September 1994. For historical feed ingredient values, feed prices from the California Grain and Feed Association (CGFA) were used. The CGFA, an industry trade group representing mostly the feed industry of California, publishes the *California Grain & Feed Market Review News.* To generate a time series history for a number of feed ingredients, the CGFA values from the Feed Market Review were used. These prices were on the first day of the month using price sheets from January 1992 to September 2004. A freight spread was used to generate delivered values for the Hanford-Visalia-Tulare (HTV) area. For a number of ingredients, the price history dates back to January 1992 though prices were FOB values at a number of locations. It was necessary to adjust those FOB values for freight to reflect delivered HTV values. Only a certain number of ingredients met the September 1994 requirement including corn, barley, hominy, almond hulls, cottonseed, and cottonseed meal. In the case of wheat millrun, sometimes known as wheat midds, the spot and forward data series started in February 2001. Chicago Board of Trade soybean meal futures contracts (beginning of the month) were used for soybean meal and adjusted by adding $33.00/ton to reflect a delivered HTV value. Other feed ingredients had spot and forward contract data series starting in August 1999, but not a CGFA time series history long enough to calculate the five-year rolling average less one-half a standard deviation which would necessitate price history at least back to September 1994. For canola meal, the CGFA price history starts in September 1997. The DDG and soyhull pellets data begin in November of 1998. So for canola meal, forward values are not incorporated until September 2002 while DDG and soyhull pellets have forward values starting in November 2003. The fact that there were no forward values for DDG, soyhull pellets, and canola meal does limit the analysis of feed cost expenditures. DDG and canola meal are two major ingredients that often find a place in the California dairy ration and forward values, if available, may have lowered average daily feed costs. Still, it is unknown as to whether a forward value for any of these feed ingredients would satisfy the requirement of being at least one-half a standard deviation below the rolling five year average. Furthermore, even if the forward value satisfied this criteria, the ration formulation model may not choose one or any of these three products if there were other ingredients that helped satisfy the nutritional requirements of the cow at a lower total cost.

California feed companies offer forward contracts in addition to spot contracts. These contracts can extend for the next month to over the next 18 months. The marketing year for California dairy producers for most feed contracts extends from October 1 to the following September 30. This period of time refers to a full clock year. As an example, at the beginning of January of 2005 a feed company can offer a one month rolled corn contract for the month of January, a three month contract covering the period January-March 2005, and a contract for the rest of this clock year (clock 1) covering the period

January through September 2005. They can also offer a contract covering the period for the next clock year (clock 2) extending from October 1, 2005 through September 30, 2006. A time series for each feed ingredient was developed, starting in August 1999 if possible. These values were compared to the spot price, 3-month forward price, clock 1 (year 1) forward price, and clock 2 (year 2) forward price if available.

Larger California feed companies publish a price sheet that lists values for the various ingredients in different time periods. For the spot and forward feed values used in the ration formulation models, prices on the first business day of the month for both spot and forward values were used in the models. To make the models as realistic as possible, the prices were delivered values into the Hanford, Visalia, Tulare region (HTV) of central California. The values listed on the price sheet are for the most part FOB values that are the prices at the mill. In an accounting procedure, it was necessary add the usual truck freight charge to estimate the values on the price sheet to the values delivered to the dairy. This was accounted for by adding $4.00 to $5.00/ton on top of the listed FOB values. In the time period covered by the ration model, for a number of feed products there are Spot, 3-month, clock 1, and clock 2 prices. The forward contracting scenario was designed so the spot contract price was used unless the forward contract value was below the five-year rolling average less one-half a standard deviation.

All feed ingredient values were converted from $/ton to $/lb. Monthly values were used and then extrapolated out on a weekly basis. It was assumed that January, May, August, and October have five weeks per month while the other months have four weeks. There were times that for whatever reason, there was no forward contract value for a particular ingredient and if that was the case and the month had not already been contracted, the spot value was used. If for some reason there was no spot value for a particular feed ingredient then a price of $1.00 per pound was used so the algorithm would not choose this ingredient. The ration model also valued fat at $0.14 per pound and molasses at $0.05 per pound and these were constant values used throughout the study period.

The following is an explanation of how the various feed ingredient values were derived along with their associated tables.

FOB CGFA Prices- These are the monthly prices at the beginning of the month for a variety of feed ingredients that are published by the California Grain and Feed Association (CGFA). The values are fob from various locations throughout the state. The only exception is column T which is the front month soybean meal futures contract traded at the Chicago Board of Trade. These values are listed in Table 4.12 in $/ton.

DLVD HTV CGFA Prices- These are the FOB CGFA monthly prices with a freight adjustment to reflect a delivered price in the Hanford-Visalia-Tulare region. These values are listed in Table 4.13 as $/ton with the freight spread adjustments in row 9 for the various ingredients. Comparisons of spot prices on the daily price sheets issued by the various feed companies vs. the fob CGFA values were used to calculate the average freight spread differential.

DLVD HTV CGFA Prices 5-year ma- These are the five-year rolling average of the monthly delivered HTV CGFA values which are listed in Table 4.14. Since most of the data from the first tab start in January of 1992, by January 1997 there is a five-year history for most ingredients. Canola meal does not start until September 2002 while distillers grain and soyhull pellet series do not start until November 2003.

One Half of Standard Deviation of DLVD HTV CGFA prices 5 year ma- These values listed in Table 4.15 are one-half of the standard deviation of the five-year rolling average of the delivered HTV CGFA prices expressed in $/ton.

DLVD HTV CGFA Prices 5-year ma less ½ Standard Deviation- These values listed in Table 4.16 are the rolling five-year average of the delivered HTV CGFA prices one-half the rolling standard deviation values. They are the values in Table 4.14 less the values in Table 4.15

Spot and Forward Feed Prices- These are the per ton prices for a variety of feed ingredients that are offered the first business day of each month. Spot prices are the prices offered for the duration of that month. The 3 month price is the price for the present month and the following two months. The Clock 1 price is the price or the period encompassing the present month through September. The Clock 2 prices are the prices for the upcoming October through September of the following or second year. These values are listed in Table 4.17 in $/ton.

Spot by Week-These are the monthly spot prices reported by each week in dollars per pound for the various feed ingredients. These values are listed in Table 4.18.

Soymeal Futures - These are the monthly prices of the spot CBT soybean meal contract the first business day of the month. These are used to calculate the benchmark soybean meal figures (rolling five-year average minus one-half a standard deviation). These values are listed in the last column in Table 4.12 in $/ton.

HTV Hay Prices – These are prices from the USDA's Agricultural Marketing Service California hay price series. Prices were taken from January 1985 to October 2004. These prices are delivered values into the HTV area on a dollar per ton basis. The supreme hay price series is used for this analysis with the hay values are listed in Table 4.19.

Prices Used – This is key page of the spreadsheet with the benchmark figures and the spot, three-month, clock 1, and clock 2 values. For Aug 99 and Sep 99 months, spot prices were used. Starting in August 1999 clock 1 values for Oct 1999-Sep 00 or clock 2 values for Oct 2000-Sep 2001 were used if those figures were below the benchmark. If the spot, three-month, or clock 1 offered prices were below the benchmark the longest term contract was used. Thus the clock 1 would be used before three-month or the three-month before the spot. If a month was not contracted for and the 3 month and clock 1 were higher than the benchmark value, the spot contract was used. The various cells are color coded and linked to which price offer was used for forward contracting purposes if this was the case. Those months that used the spot values are colored pink, those using a three-month contract used orange, those using a clock 1 contract were colored yellow, and those using a clock 2 contract are colored green. The monthly values used in $/ton are listed in Table 4.20. Note that just the first three ingredients are listed to save space and to provide a representative example.

Prices Used & Spot, $ per Ton Monthly – These are the spot monthly prices and the prices used from the prior tab. These values are the spot and forward values used in the model once they are converted to dollars per ton and adjusted for the number of weeks in a month. These values are listed in Table 4.21.

Prices Used & Spot, $ per Pound Monthly – These are the spot monthly prices and the prices used from the prior tab adjusted to a per pound basis. These values are listed in Table 4.22.

Prices Used & Spot, $ per Pound Weekly – These are the spot monthly prices and the prices used from the prior tab adjusted to a per pound basis and put on a weekly basis. These values are listed in Table 4.23.

Spot Values by Week – These are the spot prices in dollars per pound and these are the values used in the model. These values are listed in Table 4.9.

Forward Values by Week – These are the forward prices in dollars per pound and these are the values used in the model. These values are listed in Table 4.10.

4.8 Milk Prices

In the ration model, the Federal Milk Marketing Order Class III cash and futures value is used as the milk price variable. Though California dairy producers receive the state overbase formula for the milk price received, in order to gauge the effects of forward contracting, results were calculated with the Class III price. Using the profit-maximization model, which incorporates the milk price as part of its algorithm, a producer can forward contract milk prices via the milk futures market or else just accept the spot price. The Class III milk futures market traded at the Chicago Mercantile Exchange is a cash settled contract tied into the announced Federal Class III price, generally released the fifth business day of the following month. For example, the December 2001 Federal Class III milk price was announced in early January and it is assumed that producers who had not forward contracted with futures would receive that price. Starting in January of 1999, a producer has on the first day of the month the prices of all Class III contracts for the next twelve months. Note that in January of 1999, the milk futures market traded at the Chicago Mercantile Exchange was relatively new. Initially only eleven months worth of data were listed, though as the contract matured, more deferred contracts were listed. It now has become possible to theoretically sell one year's worth of milk production in the futures market using a twelve month strip. A strip is consecutive futures months averaged together and one can actually execute a strip trade on the floor. If the futures price for any particular month or strip of months is above a certain level then the producer will forward contract all or a portion of that month's estimated production. Otherwise, the producer will just receive the cash price which in this case is the monthly FMMO Class III value.

For this paper, two different forward contract scenarios are used although the benchmark for each is the same. For either method, any forward contracting must be done at a price which is the five-year rolling moving average of the cash Class III contract plus one standard deviation. Using the Class III-BFP price data going back a number of years, the rolling five-year average plus one standard deviation was calculated from the period January 1999 to December 2004. The rolling as opposed to the fixed average was chosen in order that the calculated benchmark incorporated more of the recent price history. Similarly, the standard deviation uses a five-year rolling history to reflect more recent trends in price volatility. For instance, in January 1999, the five-year Class III-BFP average covering the period from January 1994 to December 1998 was $12.70 and the standard deviation for that same time period was $1.49. So in January 1999, with either method, in order to forward contract, the individual months or strips of months had to be over the sum of the five-year rolling moving average and standard deviation which in this case was $14.19. By September 2004, the forward contracting criteria was based on a five-year rolling average of $11.80 covering the period from September 1999 to August 2004 and the standard deviation for that same time period was $2.70. So any forward contracting activity beginning with the September 2004 futures contract had to be over $14.50. Note that the five-year rolling moving average milk price from January 1999 to September 2004 has fallen close to a dollar yet the volatility in milk prices as measured by the rolling five-year standard deviation has close to doubled. The rationale for forward contracting milk was to only engage in this activity if the offered future prices looked particularly attractive using the criteria. That is by forward contracting only when the price was above the rolling five-year average plus one standard deviation meant that the forward contracted prices were within the upper 16% of the range that had prevailed over the past five years. Assuming dairy producers have no knowledge as to where future milk prices will go, there is no sense in contracting at an average price since those producers who have not forward contracted, are guaranteed the "average" price over time.

For milk forward contracting purposes, two scenarios were formulated. For the Strips Month Model (SMM), the various Class III milk futures prices at the beginning of each month were used. From these, the 3, 6, and 12 month strips of futures were calculated. Note that with new Class III futures contract beginning January 1999, there were times when there was not a liquid contract 12 months into the future so the 12 month strip only used 11 months worth of data. Starting in January 1999, the 3, 6, and 12 month strips were compared to the benchmark. If the 12 month strip was equal to or greater than the benchmark, 50% of the milk for the next 12 months would be sold at that price with the other half priced at the spot or cash Class III value. In Table 4.24 these are the milk prices highlighted in green. If the 12 month strip price was below the benchmark, the 6 month strip was examined to see if it was equal to or greater than the benchmark. If so, 33% of the milk for next 6 months would be sold at that price and the other 67% priced at the spot or class III value. In Table 4.24 these are the milk prices highlighted in yellow. If the 6 month strip price was below the benchmark then the 3 month strip examined to see if it was equal to or greater than the benchmark. If so, 25% of the milk for next 3 months was sold at that price with the other 75% priced at the spot or monthly BFP value. In Table 4.24 these are the milk prices highlighted in orange. Finally, if neither the 12, 6, or 3 month strips of futures were above the benchmark milk values would just default to the spot price. The rational for using different percentages was the willingness to forward contract larger amounts of milk if the forward contracted price was attractive.

The other forward pricing scenario is the Individual Months Model (IMM) where a producer can forward contract any or all of the twelve months worth of futures prices at the beginning of the month. If any particular month is over the assigned benchmark (five-year rolling average plus one standard deviation), 100% of that month's production is priced at that point. It is assumed that any listed price at the beginning of the month can be forward contracted though not more than 100% sold for any month. In Table 4.25, those months that have been forward contracted are shaded orange. Those cells that are shaded purple are months that could have been forward contracted but already were since at some point prior, the futures contract for that particular month was above the assigned benchmark. There are times when at the beginning of the month that none of the values for futures contracts over the next 12 months will be over the assigned target level and there will be instances where perhaps all months are.

Table 4.1.1: Ration Model Columns A-L

Week of lactation	Actual week	Body weight in lbs	lbs milk/ day	Milk fat %	lbs 3.5% FCM/day	lbs 4% FCM/day	Max of 3 DMI models	Daily Nel, Mcal	Daily Crude protein, lb	Milk price, $/cwt	Predicted milk production
1	Aug 99-1	1430	66.0	4.10	72.42	66.99	46.17	32.29	6.96	16.20	71.05
2	Aug 99-2	1415	69.3	4.00	74.92	69.30	46.61	33.04	7.17	16.20	72.20
3	Aug 99-3	1400	72.6	3.90	77.31	71.51	47.01	33.77	7.38	16.20	73.28
4	Aug 99-4	1385	75.9	3.80	79.59	73.62	47.39	34.46	7.57	16.20	74.31
5	Aug 99-5	1370	79.2	3.70	81.77	75.64	47.73	35.14	7.76	16.20	75.27
6	Sep 99-1	1355	82.5	3.65	84.50	78.17	48.23	35.95	7.99	16.75	76.41
7	Sep 99-2	1340	85.8	3.60	87.19	80.65	48.72	36.74	8.22	16.75	77.51
8	Sep 99-3	1325	89.1	3.55	89.82	83.09	49.19	37.52	8.44	16.75	78.57
9	Sep 99-4	1315	92.4	3.50	92.40	85.47	49.74	38.32	8.66	16.75	79.62
10	Oct 99-1	1310	95.7	3.40	94.14	87.09	50.14	38.93	8.82	16.65	80.41
11	Oct 99-2	1312	94.9	3.38	92.97	86.00	49.85	38.60	8.72	16.65	79.99
12	Oct 99-3	1314	94.1	3.35	91.81	84.93	49.84	38.28	8.63	16.65	79.56
13	Oct 99-4	1316	93.3	3.33	90.65	83.85	50.07	37.95	8.54	16.65	79.13
14	Oct 99-5	1318	92.5	3.30	89.50	82.79	50.74	37.63	8.45	16.65	78.70
15	Nov 99-1	1320	91.7	3.30	88.72	82.07	51.41	37.39	8.38	15.50	78.39
16	Nov 99-2	1322	90.9	3.33	88.32	81.70	52.09	37.25	8.34	15.50	78.20
17	Nov 99-3	1324	90.1	3.35	87.90	81.32	52.76	37.11	8.31	15.50	78.01
18	Nov 99-4	1326	89.3	3.38	87.49	80.93	53.44	36.97	8.27	15.50	77.82
19	Dec 99-1	1328	88.5	3.40	87.06	80.54	54.12	36.82	8.23	14.60	77.62
20	Dec 99-2	1330	87.7	3.40	86.27	79.81	54.80	36.59	8.16	14.60	77.30
21	Dec 99-3	1335	86.2	3.42	85.01	78.64	54.33	36.20	8.06	14.60	76.77
22	Dec 99-4	1340	84.7	3.43	83.74	77.46	53.87	35.82	7.95	14.60	76.24
23	Jan 00-1	1345	83.2	3.45	82.45	76.27	53.40	35.43	7.84	10.05	75.70
24	Jan 00-2	1350	81.7	3.46	81.17	75.08	52.92	35.05	7.73	10.05	75.15
25	Jan 00-3	1355	80.2	3.48	79.87	73.88	52.44	34.66	7.62	10.05	74.59
26	Jan 00-4	1360	78.7	3.49	78.57	72.68	51.95	34.27	7.52	10.05	74.02
27	Jan 00-5	1365	77.2	3.51	77.26	71.47	51.46	33.87	7.41	10.05	73.44
28	Feb 00-1	1370	75.7	3.52	75.94	70.25	50.96	33.48	7.29	9.54	72.85

29	Feb 00-2	1375	74.2	3.54	74.62	69.02	50.46	33.08	7.18	9.54	72.26
30	Feb 00-3	1380	72.7	3.55	73.29	67.79	49.96	32.68	7.07	9.54	71.65
31	Feb 00-4	1385	71.2	3.57	71.95	66.55	49.44	32.28	6.96	9.54	71.03
32	Mar 00-1	1390	69.7	3.58	70.60	65.31	48.93	31.88	6.85	9.54	70.40
33	Mar 00-2	1395	68.2	3.60	69.25	64.06	48.41	31.48	6.73	9.54	69.76
34	Mar 00-3	1400	66.7	3.61	67.89	62.80	47.88	31.07	6.62	9.54	69.11
35	Mar 00-4	1405	65.2	3.63	66.52	61.53	47.35	30.66	6.51	9.54	68.45
36	Apr 00-1	1410	63.7	3.64	65.14	60.26	46.81	30.25	6.39	9.41	67.78
37	Apr 00-2	1415	62.2	3.66	63.76	58.98	46.27	29.84	6.28	9.41	67.10
38	Apr 00-3	1420	60.7	3.67	62.37	57.70	45.72	29.43	6.16	9.41	66.40
39	Apr 00-4	1425	59.2	3.69	60.97	56.40	45.17	29.02	6.04	9.41	65.69
40	May 00-1	1430	57.7	3.70	59.57	55.10	44.62	28.60	5.93	9.37	64.96
41	May 00-2	1435	56.2	3.72	58.16	53.80	44.05	28.18	5.81	9.37	64.22
42	May 00-3	1440	54.7	3.73	56.74	52.48	43.49	27.76	5.69	9.37	63.47
43	May 00-4	1445	53.2	3.75	55.31	51.17	41.62	27.34	5.57	9.37	62.71
44	May 00-5	1450	51.7	3.76	53.88	49.84	41.30	26.91	5.45	9.37	61.92

Table 4.1.2 Ration Model Columns M-AC

	Alfalfa Early bloom	Almond Hulls	Barley grain	Beet Pulp	Canola Meal	Corn grain, flaked	Cottonseed, whole fuzzy	Cottonseed Meal 41%	Dried Distillers Grain, corn	Fat	Hominy	Molasses	Rice Bran	Soybean Hulls, pelleted	Soybean Meal 48%	Wheat Middlings
NE Lactate, Mcal/lb DM	0.61	0.85	0.88	0.81	0.73	0.93	1.02	0.83	0.99	2.65	0.96	0.74	0.59	0.85	0.86	0.87
CP %DM	0.18	0.045	0.14	0.097	0.406	0.102	0.24	0.456	0.25	0	0.115	0.04	0.143	0.121	0.55	0.19
Ca %DM	1.41	0.21	0.05	0.69	0.67	0.02	0.15	0.22	0.15	0.00	0.06	1.19	0.08	0.49	0.99	0.12
P %DM	0.22	0.10	0.37	0.08	1.04	0.31	0.73	1.21	0.71	0.00	0.58	0.11	1.59	0.21	0.73	1.00
DM%	0.9	0.9	0.89	0.91	0.91	0.86	0.92	0.91	0.92	0.99	0.9	0.75	0.91	0.91	0.89	0.89
Price/lb wk 1	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
Price/lb wk 2	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
Price/lb wk 3	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
Price/lb wk 4	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
Price/lb wk 5	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
Price/lb wk 6	0.05927	0.0285	0.0545	0.0575	0.069	0.052	0.0815	0.077	1	0.14	0.049	0.05	1	0.0435	0.085	1
Price/lb wk 7	0.05927	0.0285	0.0545	0.0575	0.069	0.052	0.0815	0.077	1	0.14	0.049	0.05	1	0.0435	0.085	1
Price/lb wk 8	0.05927	0.0285	0.0545	0.0575	0.069	0.052	0.0815	0.077	1	0.14	0.049	0.05	1	0.0435	0.085	1
Price/lb wk 9	0.05927	0.0285	0.0545	0.0575	0.069	0.052	0.0815	0.077	1	0.14	0.049	0.05	1	0.0435	0.085	1
Price/lb wk 10	0.05723	0.0315	0.0595	0.0595	0.064	0.057	0.0815	0.0635	0.0575	0.14	0.055	0.05	1	0.0425	0.092	1
Price/lb wk 11	0.05723	0.0315	0.0595	0.0595	0.064	0.057	0.0815	0.0635	0.0575	0.14	0.055	0.05	1	0.0425	0.092	1
Price/lb wk 12	0.05723	0.0315	0.0595	0.0595	0.064	0.057	0.0815	0.0635	0.0575	0.14	0.055	0.05	1	0.0425	0.092	1
Price/lb wk 13	0.05723	0.0315	0.0595	0.0595	0.064	0.057	0.0815	0.0635	0.0575	0.14	0.055	0.05	1	0.0425	0.092	1
Price/lb wk 14	0.05723	0.0315	0.0595	0.0595	0.064	0.057	0.0815	0.0635	0.0575	0.14	0.055	0.05	1	0.0425	0.092	1
Price/lb wk 15	0.06063	0.032	0.0595	0.059	0.0615	0.057	0.0815	0.0635	0.059	0.14	0.055	0.05	1	0.045	0.092	1
Price/lb wk 16	0.06063	0.032	0.0595	0.059	0.0615	0.057	0.0815	0.0635	0.059	0.14	0.055	0.05	1	0.045	0.092	1
Price/lb wk 17	0.06063	0.032	0.0595	0.059	0.0615	0.057	0.0815	0.0635	0.059	0.14	0.055	0.05	1	0.045	0.092	1
Price/lb wk 18	0.06063	0.032	0.0595	0.059	0.0615	0.057	0.0815	0.0635	0.059	0.14	0.055	0.05	1	0.045	0.092	1
Price/lb wk 19	0.06424	1	0.0595	0.0635	0.065	0.057	0.0815	0.0635	0.057	0.14	0.055	0.05	1	0.045	0.092	1
Price/lb wk 20	0.06424	1	0.0595	0.0635	0.065	0.057	0.0815	0.0635	0.057	0.14	0.055	0.05	1	0.045	0.092	1
Price/lb wk 21	0.06424	1	0.0595	0.0635	0.065	0.057	0.0815	0.0635	0.057	0.14	0.055	0.05	1	0.045	0.092	1

Price/lb wk 22	0.06424	1	0.0595	0.0635	0.065	0.057	0.0815	0.0635	0.057	0.14	0.055	0.05	1	0.045	0.092	1
Price/lb wk 23	0.06665	1	0.0595	1	0.068	0.057	0.0815	0.0625	0.061	0.14	0.055	0.05	1	0.0445	0.092	1
Price/lb wk 24	0.06665	1	0.0595	1	0.068	0.057	0.0815	0.0625	0.061	0.14	0.055	0.05	1	0.0445	0.092	1
Price/lb wk 25	0.06665	1	0.0595	1	0.068	0.057	0.0815	0.0625	0.061	0.14	0.055	0.05	1	0.0445	0.092	1
Price/lb wk 26	0.06665	1	0.0595	1	0.068	0.057	0.0815	0.0625	0.061	0.14	0.055	0.05	1	0.0445	0.092	1
Price/lb wk 27	0.06665	1	0.0595	1	0.068	0.057	0.0815	0.0625	0.061	0.14	0.055	0.05	1	0.0445	0.092	1
Price/lb wk 28	0.06583	1	0.0595	1	0.074	0.057	0.0815	0.0625	0.0595	0.14	0.055	0.05	1	0.043	0.092	1
Price/lb wk 29	0.06583	1	0.0595	1	0.074	0.057	0.0815	0.0625	0.0595	0.14	0.055	0.05	1	0.043	0.092	1
Price/lb wk 30	0.06583	1	0.0595	1	0.074	0.057	0.0815	0.0625	0.0595	0.14	0.055	0.05	1	0.043	0.092	1
Price/lb wk 31	0.06583	1	0.0595	1	0.074	0.057	0.0815	0.0625	0.0595	0.14	0.055	0.05	1	0.043	0.092	1
Price/lb wk 32	0.0649	0.0425	0.0595	1	0.072	0.057	0.0815	1	0.0595	0.14	0.055	0.05	1	0.0435	0.092	1
Price/lb wk 33	0.0649	0.0425	0.0595	1	0.072	0.057	0.0815	1	0.0595	0.14	0.055	0.05	1	0.0435	0.092	1
Price/lb wk 34	0.0649	0.0425	0.0595	1	0.072	0.057	0.0815	1	0.0595	0.14	0.055	0.05	1	0.0435	0.092	1
Price/lb wk 35	0.0649	0.0425	0.0595	1	0.072	0.057	0.0815	1	0.0595	0.14	0.055	0.05	1	0.0435	0.092	1
Price/lb wk 36	0.06488	0.0425	0.0595	0.0635	0.066	0.057	0.0815	1	0.058	0.14	0.055	0.05	1	0.046	0.092	1
Price/lb wk 37	0.06488	0.0425	0.0595	0.0635	0.066	0.057	0.0815	1	0.058	0.14	0.055	0.05	1	0.046	0.092	1
Price/lb wk 38	0.06488	0.0425	0.0595	0.0635	0.066	0.057	0.0815	1	0.058	0.14	0.055	0.05	1	0.046	0.092	1
Price/lb wk 39	0.06488	0.0425	0.0595	0.0635	0.066	0.057	0.0815	1	0.058	0.14	0.055	0.05	1	0.046	0.092	1
Price/lb wk 40	0.0615	0.0425	0.0595	0.064	0.07	0.057	0.0815	1	0.065	0.14	0.055	0.05	1	0.048	0.092	1
Price/lb wk 41	0.0615	0.0425	0.0595	0.064	0.07	0.057	0.0815	1	0.065	0.14	0.055	0.05	1	0.048	0.092	1
Price/lb wk 42	0.0615	0.0425	0.0595	0.064	0.07	0.057	0.0815	1	0.065	0.14	0.055	0.05	1	0.048	0.092	1
Price/lb wk 43	0.0615	0.0425	0.0595	0.064	0.07	0.057	0.0815	1	0.065	0.14	0.055	0.05	1	0.048	0.092	1
Price/lb wk 44	0.0615	0.0425	0.0595	0.064	0.07	0.057	0.0815	1	0.065	0.14	0.055	0.05	1	0.048	0.092	1

Table 4.1.3: Ration Model Columns AD-AJ

Milk prod lbs/day	NEL Mcal/day	CP lbs/day	DMI lbs/day	Milk revenues $/day	Feed costs $/day	Profit $/day
89.89	47.04	6.97	54.18	14.56	3.50	11.07
91.36	48.44	7.17	55.79	14.80	3.59	11.21
92.80	49.86	7.38	57.42	15.03	3.70	11.33
94.09	51.16	7.57	58.91	15.24	3.80	11.45
82.72	40.77	7.76	47.73	13.40	3.08	10.32
96.94	54.15	7.99	66.00	16.24	3.55	12.68
99.29	56.75	8.22	67.11	16.63	3.75	12.88
99.70	57.22	8.44	69.71	16.70	3.76	12.94
104.64	63.15	8.66	73.89	17.53	4.21	13.32
87.28	44.66	8.82	51.23	14.53	3.03	11.50
86.98	44.39	8.73	50.96	14.48	3.01	11.47
86.44	43.91	8.63	50.42	14.39	2.98	11.42
103.17	61.33	8.54	72.85	17.18	4.26	12.92
100.93	58.65	8.45	69.47	16.81	4.07	12.74
87.09	44.48	8.39	51.42	13.50	3.12	10.38
87.32	44.69	8.35	52.09	13.54	3.19	10.35
88.40	45.66	8.31	52.76	13.70	3.24	10.46
88.96	46.18	8.27	53.44	13.79	3.28	10.51
87.07	44.47	8.23	54.13	12.71	3.77	8.94
87.22	44.60	8.16	54.80	12.73	3.90	8.83
86.53	43.99	8.06	54.33	12.63	3.92	8.71
86.06	43.58	7.95	53.87	12.56	3.96	8.61
86.09	43.60	7.85	53.40	8.65	3.27	5.38
87.14	44.53	7.73	52.92	8.76	3.50	5.25
85.20	42.84	7.62	52.44	8.56	3.20	5.36
86.10	43.62	7.52	51.95	8.65	3.46	5.20
86.17	43.67	7.41	51.46	8.66	3.50	5.16
84.40	42.16	7.29	51.59	8.05	3.07	4.98
83.91	41.75	7.18	51.08	8.00	3.04	4.96
82.87	40.89	7.07	50.04	7.91	2.99	4.92
82.34	40.46	6.97	49.52	7.86	2.95	4.90
83.27	41.22	6.85	48.93	7.94	3.11	4.83
82.70	40.75	6.74	48.41	7.89	3.08	4.81
82.14	40.30	6.62	47.88	7.84	3.04	4.79
81.54	39.82	6.51	47.35	7.78	3.01	4.77
80.93	39.34	6.39	46.81	7.62	2.99	4.63
80.30	38.85	6.28	46.27	7.56	2.96	4.60
79.58	38.29	6.17	45.73	7.49	2.85	4.63
79.35	38.11	6.04	45.17	7.47	3.08	4.39
78.70	37.62	5.93	44.62	7.37	2.99	4.38
77.90	37.03	5.81	44.05	7.30	2.93	4.37
77.23	36.53	5.69	43.49	7.24	2.90	4.33
75.25	35.12	5.57	41.62	7.05	2.80	4.25
74.71	34.74	5.45	41.30	7.00	2.77	4.23

Table 4.1.4: Ration Model Columns AK-AZ

Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed
Alfalfa Early bloom	Almond Hulls	Barley grain	Beet Pulp	Canola Meal	Corn grain, flaked	Cottonseed, whole fuzzy	Cottonseed Meal 41%	Dried Distillers Grain, corn	Fat	Hominy	Molasses	Rice Bran	Soybean Hulls, pelleted	Soybean Meal 48%	Wheat Middlings
21.67	0.01	0.00	0.00	0.00	22.85	0.00	0.00	0.00	1.63	13.55	1.63	0.00	0.00	0.00	0.00
22.31	0.00	0.00	0.00	0.00	23.53	0.00	0.00	0.00	1.67	13.95	1.67	0.00	0.00	0.00	0.00
22.97	0.00	0.00	0.00	0.00	24.22	0.00	0.00	0.00	1.72	14.35	1.72	0.00	0.00	0.00	0.00
23.56	0.00	0.00	0.00	0.00	24.85	0.00	0.00	0.00	1.77	14.73	1.77	0.00	0.00	0.00	0.00
19.09	0.00	3.38	7.40	0.00	3.02	0.00	0.00	11.08	1.43	3.20	0.00	0.00	4.09	0.00	0.00
26.41	16.50	0.18	0.21	0.00	0.52	0.00	0.01	0.00	1.98	2.13	0.20	0.00	24.78	0.00	0.00
26.84	16.78	0.00	0.00	0.00	0.47	1.45	0.00	0.00	2.01	16.78	0.00	0.00	9.91	0.00	0.00
27.88	17.43	0.20	0.22	0.00	0.55	0.00	0.01	0.01	2.09	2.44	0.21	0.00	25.97	0.00	0.00
29.56	18.47	0.00	0.00	0.00	13.77	0.00	0.01	0.00	2.22	18.47	0.00	0.00	0.00	0.00	0.00
20.49	12.55	0.00	0.00	0.00	0.00	0.00	0.00	21.70	1.54	0.00	0.00	0.00	0.00	0.00	0.00
20.38	12.74	0.00	0.00	0.00	0.00	0.00	0.00	21.34	1.53	0.01	0.00	0.00	0.00	0.00	0.00
20.17	12.60	0.00	0.00	0.00	0.01	0.00	0.00	21.11	1.51	0.00	0.00	0.00	0.00	0.00	0.00
29.13	18.21	1.93	2.69	0.00	3.30	0.00	0.00	0.00	2.19	18.21	2.19	0.00	3.35	0.00	0.00
27.79	17.37	1.78	2.07	0.00	2.86	0.00	0.00	2.29	2.08	16.07	2.00	0.00	3.05	0.00	0.00
20.57	12.85	0.00	0.00	0.00	0.68	0.00	0.00	18.15	1.54	0.87	0.00	0.00	1.92	0.00	0.00
20.83	13.02	0.00	4.13	0.00	0.00	0.00	0.00	17.73	1.56	0.00	0.00	0.00	0.00	0.00	0.00
21.10	13.19	0.00	0.00	0.00	5.70	0.00	0.00	16.76	1.58	0.00	0.00	0.00	0.00	0.00	0.00
21.38	13.36	0.00	0.00	0.00	6.95	0.00	0.00	15.89	1.60	0.00	0.00	0.00	0.00	0.00	0.00
21.65	0.00	3.46	13.90	1.44	4.57	1.03	1.79	0.41	1.62	3.49	0.20	0.00	6.40	0.00	0.00
21.92	0.00	1.22	22.58	0.87	1.95	1.58	1.72	1.48	1.64	2.00	0.31	0.00	3.22	0.00	0.00
21.73	0.00	0.51	26.58	0.79	0.91	2.00	1.71	1.47	1.63	1.06	0.00	0.00	1.44	0.00	0.00
21.55	0.00	0.00	29.14	0.53	0.00	3.51	1.50	1.21	1.62	0.14	0.06	0.00	0.00	0.00	0.00
21.36	0.00	0.00	0.00	0.00	0.00	0.00	1.45	0.00	1.60	0.00	0.00	0.00	34.36	0.00	0.00
21.17	0.00	3.42	0.00	0.00	9.08	0.00	0.00	4.78	1.59	0.63	1.27	0.00	17.05	0.00	0.00
20.98	0.00	0.00	0.00	0.00	0.00	0.00	1.16	0.00	1.58	0.00	0.00	0.00	33.99	0.00	0.00
20.78	0.00	2.76	0.00	0.15	11.47	0.00	0.30	3.53	1.56	0.00	1.56	0.00	16.01	0.00	0.00
20.58	0.00	6.09	0.00	0.00	11.89	0.00	1.30	0.00	1.54	6.77	0.00	0.00	9.31	0.00	0.00

20.64	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.11	1.55	0.00	0.00	0.00	34.06	0.00	0.00
20.43	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.11	1.53	0.00	0.00	0.00	33.86	0.00	0.00
20.03	0.00	0.01	0.00	0.10	0.00	0.04	0.13	0.05	1.50	0.00	0.00	0.00	33.07	0.15	0.00
19.82	0.00	0.01	0.00	0.08	0.00	0.03	0.10	0.04	1.49	0.00	0.00	0.00	32.83	0.12	0.00
19.57	12.23	1.66	0.00	0.00	1.38	0.00	0.00	8.31	1.47	1.45	1.34	0.00	6.86	0.00	0.00
19.36	12.10	1.67	0.00	0.00	1.48	0.00	0.00	7.97	1.45	1.48	1.46	0.00	6.74	0.00	0.00
19.15	11.97	1.82	0.00	0.00	1.63	0.00	0.00	7.43	1.44	1.68	1.24	0.00	6.77	0.00	0.00
18.94	11.84	1.82	0.00	0.00	1.71	0.00	0.00	7.11	1.42	1.70	1.42	0.00	6.61	0.00	0.00
18.73	11.70	1.56	0.67	0.00	1.28	0.00	0.00	6.77	1.40	2.22	1.32	0.00	6.27	0.00	0.00
18.51	11.57	1.49	0.64	0.00	1.28	0.00	0.00	6.40	1.39	2.24	1.33	0.00	6.50	0.00	0.01
18.30	11.43	0.94	0.00	0.00	0.00	0.00	0.00	5.09	1.37	2.47	0.00	0.00	10.84	0.00	0.00
18.07	11.29	1.92	4.44	0.00	2.32	5.49	0.00	0.57	1.36	2.27	0.00	0.00	2.25	0.00	0.00
17.85	11.15	1.92	3.06	0.00	2.32	5.55	0.00	0.53	1.35	2.27	1.34	0.00	2.25	0.00	0.00
17.62	11.01	1.88	3.44	0.00	2.30	4.18	0.00	1.44	1.32	2.24	1.32	0.00	2.22	0.00	0.00
17.40	10.87	1.88	3.60	0.00	2.28	4.78	0.00	0.49	1.30	2.23	1.30	0.00	2.21	0.00	0.00
16.65	10.40	1.72	2.80	0.00	2.07	5.54	0.00	0.52	1.25	2.03	1.25	0.00	2.02	0.00	0.00
16.52	10.33	1.71	3.36	0.00	2.06	4.94	0.00	0.49	1.24	2.02	1.24	0.00	2.01	0.00	0.00
18.47	11.54	0.95	0.99	0.00	0.94	11.87	0.00	0.94	1.40	1.00	0.90	1.02	1.03	0.00	0.00
18.64	11.65	0.47	0.00	0.00	0.90	0.00	0.01	12.46	1.40	1.49	0.00	2.11	2.25	0.00	0.00
18.80	10.10	0.00	0.00	0.00	0.01	0.00	0.00	11.37	1.41	0.00	0.00	10.04	0.00	0.00	0.00
18.95	11.85	0.00	3.76	3.30	0.00	0.00	0.00	8.21	1.42	0.64	0.00	2.22	1.79	0.07	0.00
19.09	11.93	0.00	0.00	0.00	0.69	0.00	0.00	16.36	1.43	1.41	0.00	0.21	1.34	0.08	0.00
19.29	12.02	0.00	0.00	0.04	0.00	0.00	0.00	17.80	1.45	2.05	0.00	0.00	0.35	0.04	0.00
19.49	9.35	0.00	0.00	0.00	0.54	0.00	0.00	17.87	1.46	2.12	0.00	0.00	2.75	0.00	0.00
19.68	6.12	0.00	0.00	7.78	0.04	0.00	0.00	0.15	1.48	0.20	0.00	0.03	18.74	0.01	0.00
19.89	12.41	0.00	0.00	1.30	0.30	0.00	0.00	4.87	1.14	0.58	0.00	9.69	0.91	3.87	0.00
20.06	3.94	0.00	0.00	2.78	0.00	8.68	0.00	1.56	1.50	0.27	0.00	14.05	2.29	0.00	0.00
19.94	12.42	0.00	0.00	1.43	0.00	0.00	0.00	6.64	1.12	0.00	0.00	9.22	0.93	3.34	0.00
19.94	12.46	0.00	0.00	9.27	0.00	0.00	0.00	0.00	1.50	11.36	0.00	0.00	0.00	0.60	0.00
20.03	12.33	0.00	0.00	0.06	0.00	0.00	0.00	20.34	1.50	0.00	0.00	0.00	0.72	0.05	0.00
20.30	10.15	0.00	0.02	0.00	0.47	0.00	0.00	17.99	1.52	4.05	0.02	0.01	1.32	0.00	0.00
20.57	12.85	0.60	0.41	0.75	0.49	16.99	0.00	0.86	1.54	0.59	0.26	0.00	0.72	0.00	0.00
20.83	13.02	0.69	0.49	0.23	0.59	17.13	0.00	0.93	1.56	0.71	0.33	0.00	0.86	0.00	0.00
21.10	13.19	0.77	0.54	0.00	0.68	16.77	0.00	1.00	1.58	0.82	0.77	0.00	0.99	0.00	0.00
21.38	11.32	0.00	0.00	6.70	4.60	0.00	0.00	0.38	1.60	13.36	0.00	0.00	0.00	0.00	0.00

21.65	13.53	1.14	1.15	0.00	1.12	14.05	0.00	1.32	1.62	1.18	0.62	1.19	1.19	0.00	0.00
21.92	13.70	1.11	1.42	0.00	1.10	13.38	0.00	1.28	1.64	1.16	1.64	1.16	1.17	0.00	0.00
21.73	13.58	1.11	1.63	0.00	1.11	13.18	0.00	1.07	1.63	1.17	1.63	1.16	1.17	0.00	0.00
21.55	13.47	1.14	1.74	0.00	1.14	12.76	0.00	1.04	1.62	1.21	1.62	1.18	1.20	0.00	0.00
21.36	13.35	0.02	0.00	0.12	7.47	12.71	0.00	0.84	1.60	0.00	1.50	0.00	0.36	0.12	0.00
21.17	13.23	1.07	3.05	0.00	1.17	12.72	0.00	0.67	1.59	1.18	1.59	0.00	1.18	0.00	0.00
20.97	0.00	0.00	0.00	0.05	0.00	0.00	0.00	2.73	1.57	0.07	0.00	0.00	32.23	0.06	0.00
20.78	12.99	0.18	0.00	0.00	0.00	0.00	0.00	10.34	1.56	4.86	0.00	0.00	6.57	0.00	0.00
20.58	12.87	0.12	0.00	0.00	1.76	0.00	0.00	10.87	1.54	3.38	1.55	0.00	4.39	0.00	0.00
20.39	12.74	0.18	0.00	0.00	1.83	0.00	0.00	10.44	1.53	3.45	1.53	0.00	4.46	0.00	0.00
20.18	12.62	0.19	0.00	0.00	1.87	0.00	0.00	10.02	1.51	3.52	1.51	0.00	4.55	0.00	0.00
19.98	12.49	0.31	0.00	0.00	1.95	0.00	0.00	9.58	1.50	3.56	1.50	0.00	4.56	0.00	0.00
19.78	12.36	0.00	0.00	0.70	5.54	0.00	0.00	0.00	1.48	12.36	0.39	0.00	0.00	2.51	0.00
19.57	12.23	0.07	0.00	0.00	11.02	8.41	0.00	1.36	1.47	0.36	0.00	0.01	0.00	0.00	0.00
19.36	0.00	0.00	0.00	0.46	32.65	0.00	0.00	0.04	1.45	0.00	0.00	0.00	0.00	1.14	0.00
19.15	11.97	1.10	5.94	0.00	1.45	5.43	0.00	3.69	1.44	1.51	1.44	0.00	0.00	0.00	0.00
18.94	11.84	0.16	0.20	0.00	0.17	7.03	0.00	0.54	1.42	11.84	0.22	0.00	0.00	0.00	0.00
18.73	11.67	1.51	4.49	1.99	3.22	0.05	0.00	0.04	1.40	3.64	0.04	0.00	0.00	0.00	5.25
18.51	11.57	2.05	2.26	0.39	2.75	0.00	0.00	3.90	1.39	2.99	0.63	0.00	1.69	0.00	3.29
18.29	11.43	1.88	1.99	0.10	2.53	0.00	0.00	4.46	1.37	2.79	1.38	0.00	1.46	0.00	3.24
18.07	11.29	1.86	4.12	0.00	2.29	4.88	0.00	0.45	1.36	2.24	0.06	0.00	2.14	0.00	1.25
17.85	11.15	1.86	2.80	0.00	2.27	4.91	0.00	0.44	1.34	2.23	1.34	0.00	2.18	0.00	1.27
17.62	11.01	1.84	3.07	0.00	2.26	4.51	0.00	0.42	1.32	2.22	1.32	0.00	2.16	0.00	1.25
17.40	8.79	0.37	13.76	0.01	1.53	0.12	0.05	0.13	1.30	0.72	0.00	0.00	2.50	1.42	0.00
16.65	10.40	1.15	2.49	0.00	1.46	2.29	0.00	0.00	1.25	1.42	1.25	0.00	1.37	0.00	6.66
16.52	10.33	1.91	0.00	0.00	2.61	0.00	0.00	2.43	1.24	2.78	1.24	0.00	3.01	0.00	4.00

Table 4.2: 305 Day Lactation Statistics

Week	lbs milk/day	Milk fat %	Body weight in lbs	DMI as %BW	DMI in lbs	DMI, %BW & 4%FCM	DMI per 2001 NRC	Lag factor	Maximum DMI	lbs 3.5% FCM/day	lbs 4% FCM/day	CP required, lbs. per day	NEL required, Mcal/day
1	66.0	4.10	1430	2.5	35.75	46.17	27.91	0.59	46.17	72.42	66.99	6.96	32.29
2	69.3	4.00	1415	2.63	37.21	46.61	31.72	0.66	46.61	74.92	69.30	7.17	33.04
3	72.6	3.90	1400	2.76	38.64	47.01	35.00	0.72	47.01	77.31	71.51	7.38	33.77
4	75.9	3.80	1385	2.89	40.03	47.39	37.82	0.77	47.39	79.59	73.62	7.57	34.46
5	79.2	3.70	1370	3.02	41.37	47.73	40.25	0.81	47.73	81.77	75.64	7.76	35.14
6	82.5	3.65	1355	3.15	42.68	48.23	42.53	0.84	48.23	84.50	78.17	7.99	35.95
7	85.8	3.60	1340	3.28	43.95	48.72	44.55	0.87	48.72	87.19	80.65	8.22	36.74
8	89.1	3.55	1325	3.41	45.18	49.19	46.35	0.89	49.19	89.82	83.09	8.44	37.52
9	92.4	3.50	1315	3.54	46.55	49.74	48.02	0.91	49.74	92.40	85.47	8.66	38.32
10	95.7	3.40	1310	3.67	48.08	50.14	49.33	0.93	50.14	94.14	87.09	8.82	38.93
11	94.9	3.38	1312	3.715	48.74	49.85	49.64	0.94	49.85	92.97	86.00	8.72	38.60
12	94.1	3.35	1314	3.76	49.41	49.55	49.84	0.95	49.84	91.81	84.93	8.63	38.28
13	93.3	3.33	1316	3.805	50.07	49.26	49.93	0.96	50.07	90.65	83.85	8.54	37.95
14	92.5	3.30	1318	3.85	50.74	48.97	49.94	0.97	50.74	89.50	82.79	8.45	37.63
15	91.7	3.30	1320	3.895	51.41	48.79	50.01	0.97	51.41	88.72	82.07	8.38	37.39
16	90.9	3.33	1322	3.94	52.09	48.71	50.15	0.98	52.09	88.32	81.70	8.34	37.25
17	90.1	3.35	1324	3.985	52.76	48.63	50.24	0.98	52.76	87.90	81.32	8.31	37.11
18	89.3	3.38	1326	4.03	53.44	48.55	50.29	0.98	53.44	87.49	80.93	8.27	36.97
19	88.5	3.40	1328	4.075	54.12	48.47	50.30	0.99	54.12	87.06	80.54	8.23	36.82
20	87.7	3.40	1330	4.12	54.80	48.28	50.18	0.99	54.80	86.27	79.81	8.16	36.59
21	86.2	3.42	1335	4.07	54.33	48.01	49.90	0.99	54.33	85.01	78.64	8.06	36.20
22	84.7	3.43	1340	4.02	53.87	47.74	49.60	0.99	53.87	83.74	77.46	7.95	35.82
23	83.2	3.45	1345	3.97	53.40	47.47	49.28	0.99	53.40	82.45	76.27	7.84	35.43
24	81.7	3.46	1350	3.92	52.92	47.20	48.95	1.00	52.92	81.17	75.08	7.73	35.05
25	80.2	3.48	1355	3.87	52.44	46.92	48.61	1.00	52.44	79.87	73.88	7.62	34.66
26	78.7	3.49	1360	3.82	51.95	46.65	48.26	1.00	51.95	78.57	72.68	7.52	34.27
27	77.2	3.51	1365	3.77	51.46	46.37	47.90	1.00	51.46	77.26	71.47	7.41	33.87
28	75.7	3.52	1370	3.72	50.96	46.09	47.53	1.00	50.96	75.94	70.25	7.29	33.48
29	74.2	3.54	1375	3.67	50.46	45.80	47.15	1.00	50.46	74.62	69.02	7.18	33.08
30	72.7	3.55	1380	3.62	49.96	45.52	46.77	1.00	49.96	73.29	67.79	7.07	32.68
31	71.2	3.57	1385	3.57	49.44	45.23	46.38	1.00	49.44	71.95	66.55	6.96	32.28
32	69.7	3.58	1390	3.52	48.93	44.94	45.99	1.00	48.93	70.60	65.31	6.85	31.88
33	68.2	3.60	1395	3.47	48.41	44.65	45.59	1.00	48.41	69.25	64.06	6.73	31.48
34	66.7	3.61	1400	3.42	47.88	44.35	45.19	1.00	47.88	67.89	62.80	6.62	31.07
35	65.2	3.63	1405	3.37	47.35	44.06	44.78	1.00	47.35	66.52	61.53	6.51	30.66
36	63.7	3.64	1410	3.32	46.81	43.76	44.38	1.00	46.81	65.14	60.26	6.39	30.25
37	62.2	3.66	1415	3.27	46.27	43.46	43.96	1.00	46.27	63.76	58.98	6.28	29.84
38	60.7	3.67	1420	3.22	45.72	43.16	43.55	1.00	45.72	62.37	57.70	6.16	29.43
39	59.2	3.69	1425	3.17	45.17	42.85	43.13	1.00	45.17	60.97	56.40	6.04	29.02
40	57.7	3.70	1430	3.12	44.62	42.55	42.71	1.00	44.62	59.57	55.10	5.93	28.60
41	56.2	3.72	1435	3.07	44.05	42.24	42.28	1.00	44.05	58.16	53.80	5.81	28.18
42	54.7	3.73	1440	3.02	43.49	41.93	41.85	1.00	43.49	56.74	52.48	5.69	27.76
43	53.2	3.75	1445	2.51	36.27	41.62	41.42	1.00	41.62	55.31	51.17	5.57	27.34
44	51.7	3.76	1450	2.00	29.00	41.30	40.99	1.00	41.30	53.88	49.84	5.45	26.91

Table 4.3: Net Energy for Lactation Calculations

Body weight in lbs	NEL maintenance, lb extrapolated	NEL maintenance, lb formula	Milkfat %	NEL lactation, lb extrapolated	NEL lactation, lb formula
1300	**9.600**	9.6	**3.00**	**0.2900**	0.29
1305	9.625	9.625	3.05	0.2920	0.292
1310	9.650	9.65	3.10	0.2940	0.294
1315	9.675	9.675	3.15	0.2960	0.296
1320	9.700	9.7	3.20	0.2980	0.298
1325	9.725	9.725	3.25	0.3000	0.3
1330	9.750	9.75	3.30	0.3020	0.302
1335	9.775	9.775	3.35	0.3040	0.304
1340	9.800	9.8	3.40	0.3060	0.306
1345	9.825	9.825	3.45	0.3080	0.308
1350	9.850	9.85	**3.50**	**0.3100**	0.31
1355	9.875	9.875	3.55	0.3120	0.312
1360	9.900	9.9	3.60	0.3140	0.314
1365	9.925	9.925	3.65	0.3160	0.316
1370	9.950	9.95	3.70	0.3180	0.318
1375	9.975	9.975	3.75	0.3200	0.32
1380	10.000	10	3.80	0.3220	0.322
1385	10.025	10.025	3.85	0.3240	0.324
1390	10.050	10.05	3.90	0.3260	0.326
1395	10.075	10.075	3.95	0.3280	0.328
1400	**10.100**	10.1	**4.00**	**0.3300**	0.33
1405	10.125	10.125	4.05	0.3320	0.332
1410	10.150	10.15	4.10	0.3340	0.334
1415	10.175	10.175	4.15	0.3360	0.336
1420	10.200	10.2	4.20	0.3380	0.338
1425	10.225	10.225	4.25	0.3400	0.34
1430	10.250	10.25	4.30	0.3420	0.342
1435	10.275	10.275	4.35	0.3440	0.344
1440	10.300	10.3	4.40	0.3460	0.346
1445	10.325	10.325	4.45	0.3480	0.348
1450	10.350	10.35	**4.50**	**0.3500**	0.35
1455	10.375	10.375	4.55	0.3520	0.352
1460	10.400	10.4	4.60	0.3540	0.354
1465	10.425	10.425	4.65	0.3560	0.356
1470	10.450	10.45	4.70	0.3580	0.358
1475	10.475	10.475	4.75	0.3600	0.36
1480	10.500	10.5	4.80	0.3620	0.362
1485	10.525	10.525	4.85	0.3640	0.364
1490	10.550	10.55	4.90	0.3660	0.366
1495	10.575	10.575	4.95	0.3680	0.368
1500	**10.600**	10.6	**5.00**	**0.3700**	0.37

Table 4.4: Crude Protein Calculations

Body weight in lbs	CP maintenance, lb extrapolated	CP maintenance, lb formula	Milkfat %	CP lactation, lb extrapolated	CP lactation, lb formula
1300	**0.89**	0.89	**3.00**	**0.0780**	0.078
1305	0.892	0.892	3.05	0.0786	0.0786
1310	0.894	0.894	3.10	0.0792	0.0792
1315	0.896	0.896	3.15	0.0798	0.0798
1320	0.898	0.898	3.20	0.0804	0.0804
1325	0.9	0.9	3.25	0.0810	0.081
1330	0.902	0.902	3.30	0.0816	0.0816
1335	0.904	0.904	3.35	0.0822	0.0822
1340	0.906	0.906	3.40	0.0828	0.0828
1345	0.908	0.908	3.45	0.0834	0.0834
1350	0.91	0.91	**3.50**	**0.0840**	0.084
1355	0.912	0.912	3.55	0.0846	0.0846
1360	0.914	0.914	3.60	0.0852	0.0852
1365	0.916	0.916	3.65	0.0858	0.0858
1370	0.918	0.918	3.70	0.0864	0.0864
1375	0.92	0.92	3.75	0.0870	0.087
1380	0.922	0.922	3.80	0.0876	0.0876
1385	0.924	0.924	3.85	0.0882	0.0882
1390	0.926	0.926	3.90	0.0888	0.0888
1395	0.928	0.928	3.95	0.0894	0.0894
1400	**0.93**	0.93	**4.00**	**0.0900**	0.09
1405	0.932	0.932	4.05	0.0906	0.0906
1410	0.934	0.934	4.10	0.0912	0.0912
1415	0.936	0.936	4.15	0.0918	0.0918
1420	0.938	0.938	4.20	0.0924	0.0924
1425	0.94	0.94	4.25	0.0930	0.093
1430	0.942	0.942	4.30	0.0936	0.0936
1435	0.944	0.944	4.35	0.0942	0.0942
1440	0.946	0.946	4.40	0.0948	0.0948
1445	0.948	0.948	4.45	0.0954	0.0954
1450	0.95	0.95	**4.50**	**0.0960**	0.096
1455	0.952	0.952	4.55	0.0966	0.0966
1460	0.954	0.954	4.60	0.0972	0.0972
1465	0.956	0.956	4.65	0.0978	0.0978
1470	0.958	0.958	4.70	0.0984	0.0984
1475	0.96	0.96	4.75	0.0990	0.099
1480	0.962	0.962	4.80	0.0996	0.0996
1485	0.964	0.964	4.85	0.1002	0.1002
1490	0.966	0.966	4.90	0.1008	0.1008
1495	0.968	0.968	4.95	0.1014	0.1014
1500	**0.97**	0.97	**5.00**	**0.1020**	0.102

Table 4.5: National Research Council (NRC) Nutrient Requirements for Dairy Cows

Body Weight, lb	Crude protein, lb	Nel, Mcal	TDN (lb)	Ca grams	P grams
Maintenance of mature lactating cow					
800	0.67	6.7	6.4	15	11
900	0.71	7.3	7	17	12
1000	0.76	7.9	7.6	19	14
1100	0.80	8.5	8.2	21	15
1200	0.85	9.0	8.7	23	16
1300	0.89	9.6	9.2	25	17
1400	0.93	10.1	9.8	26	20
1500	0.97	10.6	10.3	28	21
1600	1.01	11.2	10.8	30	23
1700	1.05	11.7	11.3	34	24
Add for gestation of mature dry cows					
800	1.17	2.0	1.9	10	5
900	1.29	2.2	2.1	11	5
1000	1.45	2.4	2.4	12	5
1100	1.52	2.5	2.6	13	6
1200	1.63	2.7	2.7	14	7
1300	1.73	2.9	2.9	15	7
1400	1.84	3.0	3.1	16	8
1500	1.95	3.2	3.2	17	9
1600	2.06	3.4	3.4	19	9
1700	2.16	3.5	3.6	20	9
Milk production-nutrients per pound of milk of different fat percentages					
% **fat**					
3.0	0.078	0.29	0.28	1.2	0.8
3.5	0.084	0.31	0.30	1.4	0.8
4.0	0.090	0.33	0.32	1.5	0.9
4.5	0.096	0.35	0.34	1.6	1.0
5.0	0.102	0.37	0.36	1.7	1.0
5.5	0.107	0.40	0.39	1.8	1.1
Body weight change during lactation					
Weight loss	-0.32	-2.23	-2.17	*	*
weight gain	0.32	2.32	2.26	*	*

Table 4.6: Milk Contracting Sheet

	BFP	Strips model (SMM)	Individual months model (IMM)
Aug 99-1	15.79	15.69	16.20
Aug 99-2	15.79	15.69	16.20
Aug 99-3	15.79	15.69	16.20
Aug 99-4	15.79	15.69	16.20
Aug 99-5	15.79	15.69	16.20
Sep 99-1	16.26	16.01	16.75
Sep 99-2	16.26	16.01	16.75
Sep 99-3	16.26	16.01	16.75
Sep 99-4	16.26	16.01	16.75
Oct 99-1	11.49	12.81	16.65
Oct 99-2	11.49	12.81	16.65
Oct 99-3	11.49	12.81	16.65
Oct 99-4	11.49	12.81	16.65
Oct 99-5	11.49	12.81	16.65
Nov 99-1	9.79	11.67	15.50
Nov 99-2	9.79	11.67	15.50
Nov 99-3	9.79	11.67	15.50
Nov 99-4	9.79	11.67	15.50
Dec 99-1	9.63	11.56	14.60
Dec 99-2	9.63	11.56	14.60
Dec 99-3	9.63	11.56	14.60
Dec 99-4	9.63	11.56	14.60
Jan 00-1	10.05	11.85	10.05
Jan 00-2	10.05	11.85	10.05
Jan 00-3	10.05	11.85	10.05
Jan 00-4	10.05	11.85	10.05
Jan 00-5	10.05	11.85	10.05
Feb 00-1	9.54	9.54	9.54
Feb 00-2	9.54	9.54	9.54
Feb 00-3	9.54	9.54	9.54
Feb 00-4	9.54	9.54	9.54
Mar 00-1	9.54	9.54	9.54
Mar 00-2	9.54	9.54	9.54
Mar 00-3	9.54	9.54	9.54
Mar 00-4	9.54	9.54	9.54
Apr 00-1	9.41	9.41	9.41
Apr 00-2	9.41	9.41	9.41
Apr 00-3	9.41	9.41	9.41
Apr 00-4	9.41	9.41	9.41
May 00-1	9.37	9.37	9.37
May 00-2	9.37	9.37	9.37
May 00-3	9.37	9.37	9.37
May 00-4	9.37	9.37	9.37
May 00-5	9.37	9.37	9.37
Jun 00-1	9.46	9.46	9.46
Jun 00-2	9.46	9.46	9.46

Table 4.7: Milk Production Calculation Sheet

Net energy Mcal/day	3.5% FCM lbs/day	Predicted Net energy	Week	3.5% FCM lbs/day	Predicted Net energy	Daily Nel, Mcal	lbs milk/day	Predicted
8.50	0.00	7.88	1.00	66.00	29.11	32.25	66.00	70.98
	1.00	8.04	2.00	67.00	29.70	32.99	69.30	72.12
	2.00	8.20	3.00	68.00	30.29	33.71	72.60	73.20
	3.00	8.36	4.00	69.00	30.90	34.40	75.90	74.21
	4.00	8.53	5.00	70.00	31.51	35.06	79.20	75.17
	5.00	8.70	6.00	71.00	32.14	35.86	82.50	76.30
	6.00	8.87	7.00	72.00	32.79	36.65	85.80	77.39
	7.00	9.05	8.00	73.00	33.44	37.43	89.10	78.44
	8.00	9.23	9.00	74.00	34.11	38.22	92.40	79.48
	9.00	9.42	10.00	75.00	34.79	38.83	95.70	80.28
	10.00	9.61	11.00	76.00	35.49	38.50	94.90	79.85
	11.00	9.80	12.00	77.00	36.20	38.17	94.10	79.43
10.00	12.00	9.99	13.00	78.00	36.92	37.85	93.30	79.00
	13.00	10.19	14.00	79.00	37.66	37.52	92.50	78.57
	14.00	10.40	15.00	80.00	38.41	37.29	91.70	78.26
	15.00	10.61	16.00	81.00	39.18	37.15	90.90	78.07
	16.00	10.82	17.00	82.00	39.96	37.01	90.10	77.88
	17.00	11.03	18.00	83.00	40.76	36.87	89.30	77.69
	18.00	11.25	19.00	84.00	41.58	36.73	88.50	77.49
	19.00	11.48	20.00	85.00	42.41	36.49	87.70	77.17
	20.00	11.71	21.00	86.00	43.26	36.11	86.20	76.65
	21.00	11.94	22.00	87.00	44.12	35.73	84.70	76.11
	22.00	12.18	23.00	88.00	45.01	35.35	83.20	75.57
	23.00	12.43	24.00	89.00	45.91	34.96	81.70	75.02
	24.00	12.67	25.00	90.00	46.82	34.57	80.20	74.47
	25.00	12.93	26.00	91.00	47.76	34.19	78.70	73.90
	26.00	13.19	27.00	92.00	48.72	33.79	77.20	73.32
	27.00	13.45	28.00	93.00	49.69	33.40	75.70	72.74
	28.00	13.72	29.00	94.00	50.68	33.01	74.20	72.15
	29.00	13.99	30.00	95.00	51.70	32.61	72.70	71.54
	30.00	14.27	31.00	96.00	52.73	32.21	71.20	70.93
	31.00	14.56	32.00	97.00	53.79	31.82	69.70	70.30
	32.00	14.85	33.00	98.00	54.86	31.41	68.20	69.67
	33.00	15.15	34.00	99.00	55.96	31.01	66.70	69.02
	34.00	15.45	35.00	100.00	57.08	30.61	65.20	68.36
15.00	35.00	15.76	36.00	101.00	58.22	30.20	63.70	67.69
	36.00	16.07	37.00	102.00	59.38	29.79	62.20	67.01
	37.00	16.40	38.00	103.00	60.57	29.38	60.70	66.31
	38.00	16.72	39.00	104.00	61.78	28.97	59.20	65.60
	39.00	17.06	40.00	105.00	63.02	28.55	57.70	64.88
	40.00	17.40	41.00	106.00	64.28	28.14	56.20	64.15
	41.00	17.75	42.00	107.00	65.56	27.72	54.70	63.40
	42.00	18.10	43.00	108.00	66.87	27.30	53.20	62.64
	43.00	18.46	44.00	109.00	68.21	26.88	51.70	61.86
	44.00	18.83	45.00	110.00	69.57	29.11	66.00	65.86
	45.00	19.21	46.00	111.00	70.97	29.70	67.00	66.85
	46.00	19.59	47.00	112.00	72.39	30.29	68.00	67.84
	47.00	19.99	48.00	113.00	73.83	30.90	69.00	68.83
20.00	48.00	20.39	49.00	114.00	75.31	31.51	70.00	69.82
	49.00	20.79	50.00	115.00	76.82	32.14	71.00	70.82
	50.00	21.21	51.00	116.00	78.35	32.79	72.00	71.81
	51.00	21.63	52.00	117.00	79.92	33.44	73.00	72.80

	52.00	22.07		118.00	81.52	34.11	74.00	73.79
	53.00	22.51		119.00	83.15	34.79	75.00	74.78
	54.00	22.96		120.00	84.81	35.49	76.00	75.77
	55.00	23.42		121.00	86.51	36.20	77.00	76.77
	56.00	23.88		122.00	88.24	36.92	78.00	77.76
	57.00	24.36		123.00	90.00	37.66	79.00	78.75
	58.00	24.85		124.00	91.80	38.41	80.00	79.74
	59.00	25.35		125.00	93.63	39.18	81.00	80.73
25.00	60.00	25.85				39.96	82.00	81.72
	61.00	26.37				40.76	83.00	82.72
	62.00	26.90				41.58	84.00	83.71
	63.00	27.43				42.41	85.00	84.70
	64.00	27.98				43.26	86.00	85.69
	65.00	28.54				44.12	87.00	86.68
	66.00	29.11				45.01	88.00	87.67
	67.00	29.70				45.91	89.00	88.67
	68.00	30.29				46.82	90.00	89.66
	69.00	30.90				47.76	91.00	90.65
30.00	70.00	31.51				48.72	92.00	91.64
	71.00	32.14				49.69	93.00	92.63
	72.00	32.79				50.68	94.00	93.62
	73.00	33.44				51.70	95.00	94.62
	74.00	34.11				52.73	96.00	95.61
	75.00	34.79				53.79	97.00	96.60
	76.00	35.49				54.86	98.00	97.59
	77.00	36.20				55.96	99.00	98.58
35.00	78.00	36.92				57.08	100.00	99.57
	79.00	37.66						
	80.00	38.41						
	81.00	39.18						
	82.00	39.96						
40.00	83.00	40.76						
	84.00	41.58						
	85.00	42.41						
	86.00	43.26						
45.00	87.00	44.12						
	88.00	45.01						
	89.00	45.91						
	90.00	46.82						
50.00	91.00	47.76						
	92.00	48.72						
55.00	93.00	49.69						
	94.00	50.68						
	95.00	51.70						
	96.00	52.73						
	97.00	53.79						
	98.00	54.86						
	99.00	55.96						
	100.00	57.08						

Table 4.8: Feed Ingredient Nutrient Specifications

	Alfalfa Early bloom	Almond Hulls	Barley grain	Beet Pulp	Canola Meal	Corn grain, flaked	Cottonseed, whole fuzzy	Cottonseed Meal 41%	Dried Distillers Grain, corn	Fat	Hominy	Molasses	Rice Bran	Soybean Hulls, pelleted	Soybean Meal 48%	Wheat Middlings
NE Lactate, Mcal/lb DM	0.61	0.85	0.88	0.81	0.73	0.93	1.02	0.83	0.99	2.65	0.96	0.74	0.59	0.85	0.86	0.87
CP %DM	0.18	0.045	0.14	0.097	0.406	0.102	0.24	0.456	0.25	0	0.115	0.04	0.143	0.121	0.55	0.19
Ca %DM	1.41	0.21	0.05	0.69	0.67	0.02	0.15	0.22	0.15	0.00	0.06	1.19	0.08	0.49	0.99	0.12
P %DM	0.22	0.10	0.37	0.08	1.04	0.31	0.73	1.21	0.71	0.00	0.58	0.11	1.59	0.21	0.73	1.00
DM%	0.9	0.9	0.89	0.91	0.91	0.86	0.92	0.91	0.92	0.99	0.9	0.75	0.91	0.91	0.89	0.89

Table 4.9: Spot Feed Ingredient Price History ($/lb)

Week of lactation	Actual week	Alfalfa Early bloom	Almond Hulls	Barley grain	Beet Pulp	Canola Meal	Corn grain, flaked	Cottonseed, whole fuzzy	Cottonseed Meal 41%	Dried Distillers Grain, corn	Fat	Hominy	Molasses	Rice Bran	Soybean Hulls, pelleted	Soybean Meal 48%	Wheat Middlings
1	Aug 99-1	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
2	Aug 99-2	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
3	Aug 99-3	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
4	Aug 99-4	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
5	Aug 99-5	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
6	Sep 99-1	0.05927	0.0285	0.0545	0.0575	0.069	0.052	0.0865	0.077	1	0.14	0.049	0.05	1	0.0435	0.085	1
7	Sep 99-2	0.05927	0.0285	0.0545	0.0575	0.069	0.052	0.0865	0.077	1	0.14	0.049	0.05	1	0.0435	0.085	1
8	Sep 99-3	0.05927	0.0285	0.0545	0.0575	0.069	0.052	0.0865	0.077	1	0.14	0.049	0.05	1	0.0435	0.085	1
9	Sep 99-4	0.05927	0.0285	0.0545	0.0575	0.069	0.052	0.0865	0.077	1	0.14	0.049	0.05	1	0.0435	0.085	1
10	Oct 99-1	0.05723	0.0315	0.0565	0.0595	0.064	0.0495	0.079	0.0635	0.0575	0.14	0.0505	0.05	1	0.0425	0.089	1
11	Oct 99-2	0.05723	0.0315	0.0565	0.0595	0.064	0.0495	0.079	0.0635	0.0575	0.14	0.0505	0.05	1	0.0425	0.089	1
12	Oct 99-3	0.05723	0.0315	0.0565	0.0595	0.064	0.0495	0.079	0.0635	0.0575	0.14	0.0505	0.05	1	0.0425	0.089	1
13	Oct 99-4	0.05723	0.0315	0.0565	0.0595	0.064	0.0495	0.079	0.0635	0.0575	0.14	0.0505	0.05	1	0.0425	0.089	1
14	Oct 99-5	0.05723	0.0315	0.0565	0.0595	0.064	0.0495	0.079	0.0635	0.0575	0.14	0.0505	0.05	1	0.0425	0.089	1
15	Nov 99-1	0.06063	0.032	0.0575	0.059	0.0615	0.05	0.0785	0.0625	0.059	0.14	0.052	0.05	1	0.045	0.0895	1
16	Nov 99-2	0.06063	0.032	0.0575	0.059	0.0615	0.05	0.0785	0.0625	0.059	0.14	0.052	0.05	1	0.045	0.0895	1
17	Nov 99-3	0.06063	0.032	0.0575	0.059	0.0615	0.05	0.0785	0.0625	0.059	0.14	0.052	0.05	1	0.045	0.0895	1
18	Nov 99-4	0.06063	0.032	0.0575	0.059	0.0615	0.05	0.0785	0.0625	0.059	0.14	0.052	0.05	1	0.045	0.0895	1
19	Dec 99-1	0.06424	1	0.056	0.0635	0.065	0.05	0.0785	0.064	0.057	0.14	0.0535	0.05	1	0.045	0.0905	1
20	Dec 99-2	0.06424	1	0.056	0.0635	0.065	0.05	0.0785	0.064	0.057	0.14	0.0535	0.05	1	0.045	0.0905	1
21	Dec 99-3	0.06424	1	0.056	0.0635	0.065	0.05	0.0785	0.064	0.057	0.14	0.0535	0.05	1	0.045	0.0905	1
22	Dec 99-4	0.06424	1	0.056	0.0635	0.065	0.05	0.0785	0.064	0.057	0.14	0.0535	0.05	1	0.045	0.0905	1
23	Jan 00-1	0.06665	1	0.056	1	0.068	0.05	0.084	0.0625	0.061	0.14	0.061	0.05	1	0.0445	0.0885	1
24	Jan 00-2	0.06665	1	0.056	1	0.068	0.05	0.084	0.0625	0.061	0.14	0.061	0.05	1	0.0445	0.0885	1
25	Jan 00-3	0.06665	1	0.056	1	0.068	0.05	0.084	0.0625	0.061	0.14	0.061	0.05	1	0.0445	0.0885	1
26	Jan 00-4	0.06665	1	0.056	1	0.068	0.05	0.084	0.0625	0.061	0.14	0.061	0.05	1	0.0445	0.0885	1
27	Jan 00-5	0.06665	1	0.056	1	0.068	0.05	0.084	0.0625	0.061	0.14	0.061	0.05	1	0.0445	0.0885	1
28	Feb 00-1	0.06583	1	0.057	1	0.074	0.053	0.0825	0.0675	0.0595	0.14	0.059	0.05	1	0.043	0.093	1
29	Feb 00-2	0.06583	1	0.057	1	0.074	0.053	0.0825	0.0675	0.0595	0.14	0.059	0.05	1	0.043	0.093	1
30	Feb 00-3	0.06583	1	0.057	1	0.074	0.053	0.0825	0.0675	0.0595	0.14	0.059	0.05	1	0.043	0.093	1
31	Feb 00-4	0.06583	1	0.057	1	0.074	0.053	0.0825	0.0675	0.0595	0.14	0.059	0.05	1	0.043	0.093	1
32	Mar 00-1	0.0649	0.0415	0.058	1	0.072	0.0555	0.082	1	0.0595	0.14	0.0585	0.05	1	0.0435	0.0975	1
33	Mar 00-2	0.0649	0.0415	0.058	1	0.072	0.0555	0.082	1	0.0595	0.14	0.0585	0.05	1	0.0435	0.0975	1
34	Mar 00-3	0.0649	0.0415	0.058	1	0.072	0.0555	0.082	1	0.0595	0.14	0.0585	0.05	1	0.0435	0.0975	1
35	Mar 00-4	0.0649	0.0415	0.058	1	0.072	0.0555	0.082	1	0.0595	0.14	0.0585	0.05	1	0.0435	0.0975	1
36	Apr 00-1	0.06488	0.05	0.0595	0.0635	0.066	0.058	0.083	1	0.058	0.14	0.058	0.05	1	0.046	0.101	1
37	Apr 00-2	0.06488	0.05	0.0595	0.0635	0.066	0.058	0.083	1	0.058	0.14	0.058	0.05	1	0.046	0.101	1
38	Apr 00-3	0.06488	0.05	0.0595	0.0635	0.066	0.058	0.083	1	0.058	0.14	0.058	0.05	1	0.046	0.101	1
39	Apr 00-4	0.06488	0.05	0.0595	0.0635	0.066	0.058	0.083	1	0.058	0.14	0.058	0.05	1	0.046	0.101	1
40	May 00-1	0.0615	0.0455	0.0605	0.064	0.07	0.0585	0.087	1	0.065	0.14	0.056	0.05	1	0.048	0.103	1
41	May 00-2	0.0615	0.0455	0.0605	0.064	0.07	0.0585	0.087	1	0.065	0.14	0.056	0.05	1	0.048	0.103	1
42	May 00-3	0.0615	0.0455	0.0605	0.064	0.07	0.0585	0.087	1	0.065	0.14	0.056	0.05	1	0.048	0.103	1
43	May 00-4	0.0615	0.0455	0.0605	0.064	0.07	0.0585	0.087	1	0.065	0.14	0.056	0.05	1	0.048	0.103	1
44	May 00-5	0.0615	0.0455	0.0605	0.064	0.07	0.0585	0.087	1	0.065	0.14	0.056	0.05	1	0.048	0.103	1

Table 4.10: Forward Feed Ingredient Price History ($/lb)

Week of lactation	Actual week	Alfalfa Early bloom	Almond Hulls	Barley grain	Beet Pulp	Canola Meal	Corn grain, flaked	Cottonseed, whole fuzzy	Cottonseed Meal 41%	Dried Distillers Grain, corn	Fat	Hominy	Molasses	Rice Bran	Soybean Hulls, pelleted	Soybean Meal 48%	Wheat Middlings
1	Aug 99-1	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
2	Aug 99-2	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
3	Aug 99-3	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
4	Aug 99-4	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
5	Aug 99-5	0.05967	1	0.0535	0.0585	0.07	0.053	0.089	1	0.0565	0.14	0.05	0.05	1	0.045	0.0875	1
6	Sep 99-1	0.05927	0.0285	0.0545	0.0575	0.069	0.052	0.0815	0.077	1	0.14	0.049	0.05	1	0.0435	0.085	1
7	Sep 99-2	0.05927	0.0285	0.0545	0.0575	0.069	0.052	0.0815	0.077	1	0.14	0.049	0.05	1	0.0435	0.085	1
8	Sep 99-3	0.05927	0.0285	0.0545	0.0575	0.069	0.052	0.0815	0.077	1	0.14	0.049	0.05	1	0.0435	0.085	1
9	Sep 99-4	0.05927	0.0285	0.0545	0.0575	0.069	0.052	0.0815	0.077	1	0.14	0.049	0.05	1	0.0435	0.085	1
10	Oct 99-1	0.05723	0.0315	0.0595	0.0595	0.064	0.057	0.0815	0.0635	0.0575	0.14	0.055	0.05	1	0.0425	0.092	1
11	Oct 99-2	0.05723	0.0315	0.0595	0.0595	0.064	0.057	0.0815	0.0635	0.0575	0.14	0.055	0.05	1	0.0425	0.092	1
12	Oct 99-3	0.05723	0.0315	0.0595	0.0595	0.064	0.057	0.0815	0.0635	0.0575	0.14	0.055	0.05	1	0.0425	0.092	1
13	Oct 99-4	0.05723	0.0315	0.0595	0.0595	0.064	0.057	0.0815	0.0635	0.0575	0.14	0.055	0.05	1	0.0425	0.092	1
14	Oct 99-5	0.05723	0.0315	0.0595	0.0595	0.064	0.057	0.0815	0.0635	0.0575	0.14	0.055	0.05	1	0.0425	0.092	1
15	Nov 99-1	0.06063	0.032	0.0595	0.059	0.0615	0.057	0.0815	0.0635	0.059	0.14	0.055	0.05	1	0.045	0.092	1
16	Nov 99-2	0.06063	0.032	0.0595	0.059	0.0615	0.057	0.0815	0.0635	0.059	0.14	0.055	0.05	1	0.045	0.092	1
17	Nov 99-3	0.06063	0.032	0.0595	0.059	0.0615	0.057	0.0815	0.0635	0.059	0.14	0.055	0.05	1	0.045	0.092	1
18	Nov 99-4	0.06063	0.032	0.0595	0.059	0.0615	0.057	0.0815	0.0635	0.059	0.14	0.055	0.05	1	0.045	0.092	1
19	Dec 99-1	0.06424	1	0.0595	0.0635	0.065	0.057	0.0815	0.0635	0.057	0.14	0.055	0.05	1	0.045	0.092	1
20	Dec 99-2	0.06424	1	0.0595	0.0635	0.065	0.057	0.0815	0.0635	0.057	0.14	0.055	0.05	1	0.045	0.092	1
21	Dec 99-3	0.06424	1	0.0595	0.0635	0.065	0.057	0.0815	0.0635	0.057	0.14	0.055	0.05	1	0.045	0.092	1
22	Dec 99-4	0.06424	1	0.0595	0.0635	0.065	0.057	0.0815	0.0635	0.057	0.14	0.055	0.05	1	0.045	0.092	1
23	Jan 00-1	0.06665	1	0.0595	1	0.068	0.057	0.0815	0.0625	0.061	0.14	0.055	0.05	1	0.0445	0.092	1
24	Jan 00-2	0.06665	1	0.0595	1	0.068	0.057	0.0815	0.0625	0.061	0.14	0.055	0.05	1	0.0445	0.092	1
25	Jan 00-3	0.06665	1	0.0595	1	0.068	0.057	0.0815	0.0625	0.061	0.14	0.055	0.05	1	0.0445	0.092	1
26	Jan 00-4	0.06665	1	0.0595	1	0.068	0.057	0.0815	0.0625	0.061	0.14	0.055	0.05	1	0.0445	0.092	1
27	Jan 00-5	0.06665	1	0.0595	1	0.068	0.057	0.0815	0.0625	0.061	0.14	0.055	0.05	1	0.0445	0.092	1

28	Feb 00-1	0.06583	1	0.0595	1	0.074	0.057	0.0815	0.0625	0.0595	0.14	0.055	0.05	1	0.043	0.092	1
29	Feb 00-2	0.06583	1	0.0595	1	0.074	0.057	0.0815	0.0625	0.0595	0.14	0.055	0.05	1	0.043	0.092	1
30	Feb 00-3	0.06583	1	0.0595	1	0.074	0.057	0.0815	0.0625	0.0595	0.14	0.055	0.05	1	0.043	0.092	1
31	Feb 00-4	0.06583	1	0.0595	1	0.074	0.057	0.0815	0.0625	0.0595	0.14	0.055	0.05	1	0.043	0.092	1
32	Mar 00-1	0.0649	0.0425	0.0595	1	0.072	0.057	0.0815	1	0.0595	0.14	0.055	0.05	1	0.0435	0.092	1
33	Mar 00-2	0.0649	0.0425	0.0595	1	0.072	0.057	0.0815	1	0.0595	0.14	0.055	0.05	1	0.0435	0.092	1
34	Mar 00-3	0.0649	0.0425	0.0595	1	0.072	0.057	0.0815	1	0.0595	0.14	0.055	0.05	1	0.0435	0.092	1
35	Mar 00-4	0.0649	0.0425	0.0595	1	0.072	0.057	0.0815	1	0.0595	0.14	0.055	0.05	1	0.0435	0.092	1
36	Apr 00-1	0.06488	0.0425	0.0595	0.0635	0.066	0.057	0.0815	1	0.058	0.14	0.055	0.05	1	0.046	0.092	1
37	Apr 00-2	0.06488	0.0425	0.0595	0.0635	0.066	0.057	0.0815	1	0.058	0.14	0.055	0.05	1	0.046	0.092	1
38	Apr 00-3	0.06488	0.0425	0.0595	0.0635	0.066	0.057	0.0815	1	0.058	0.14	0.055	0.05	1	0.046	0.092	1
39	Apr 00-4	0.06488	0.0425	0.0595	0.0635	0.066	0.057	0.0815	1	0.058	0.14	0.055	0.05	1	0.046	0.092	1
40	May 00-1	0.0615	0.0425	0.0595	0.064	0.07	0.057	0.0815	1	0.065	0.14	0.055	0.05	1	0.048	0.092	1
41	May 00-2	0.0615	0.0425	0.0595	0.064	0.07	0.057	0.0815	1	0.065	0.14	0.055	0.05	1	0.048	0.092	1
42	May 00-3	0.0615	0.0425	0.0595	0.064	0.07	0.057	0.0815	1	0.065	0.14	0.055	0.05	1	0.048	0.092	1
43	May 00-4	0.0615	0.0425	0.0595	0.064	0.07	0.057	0.0815	1	0.065	0.14	0.055	0.05	1	0.048	0.092	1
44	May 00-5	0.0615	0.0425	0.0595	0.064	0.07	0.057	0.0815	1	0.065	0.14	0.055	0.05	1	0.048	0.092	1

Table 4.11: Solver Function

	Beginning	End		
Rows	8	271		
Target Column	AI			
Equal To (1=max, 2=min)	2			
	Beginning	End		
By Changing Columns	AK	AZ		
Constraint List	SetCell	Relation	ConstCell	
Relation with <= is 1	AE	3	$I	Energy
Relation with = is 2	AF	2	$J	Protein
Relation with >= is 3	AG	3	$H	DMI
	AU	1	0.25*$AG	HOMINY
	AK	3	0.4*$AG	ALFALFA
	AL	1	0.25*$AG	ALMOND
	AT	1	0.03*$AG	FAT
	AV	1	0.03*$AG	MOLASSES

Table 4.12: Feed Ingredient Values FOB CGFA Prices ($/ton)

	California Grain & Feed Market Review News																		
	10-Day Shipment Bulk - Terms: Net Cash - Avg Bid/Ask Blank = N/A or UNQ																		
	Almond Hulls Whole Del LA	Beet Pulp Shreds FOB Plant	Beet Pulp Pellets FOB	Canola Meal Pellets UP/FOB	Corn Hominy 4% UP N/C	Cotton-seed Whole FOB (Cor No)	Distiller's Dry Grain Dlvd Rail	Millrun FOB N/C	Soyhull Pellets UP	Barley (Tulare Market)	Rice Bran (fob plant)	Corn Gluten Meal	Cottonseed Hulls	Safflower Meal	Meat & Bone Meal	Corn Tulare Mrkt (Truck)	Corn Tulare Mrkt (Rail)	Cottonseed Meal 41%	Soymeal Futures Monthly
JAN 1992	74.5	120.0	117.0		128.0	133.5		98.0		5.99	72.0	340.0	28.5	92.0	---	6.0	5.7	174.5	175.8
FEB 1992	70.0	121.5	122.0		138.0	135.0		111.5		6.18	77.0	315.0	36.0	92.0	---	6.28	6.05	175.5	174.1
MAR 1992	68.0	125.5	UNQ		133.0	152.0		103.0		6.17	72.0	325.0	41.0	92.0	---	6.32	6.17	166.5	178.7
APR 1993	66.0	121.5	124.0		132.0	151.0		85.0		6.25	67.5	315.0	42.0	87.5	---	6.17	6	167.5	172.9
MAY 1992	65.0	115.0	118.0		131.5	156.0		99.0		6.08	68.0	290.0	46.0	87.0	---	6.12	5.97	168.0	183.2
JUN 1992	63.0	113.0	118.0		128.0	153.0		91.5		6.10	68.0	305.0	48.0	77.0	---	6.23	6.07	172.0	180.6
JUL 1992	66.0	118.0	118.0		128.0	175.0		98.5		6.23	72.0	305.0	50.0	66.0	---	6.23	6.07	178.0	174.4
AUG 1992	68.0	104.0	108.0		123.0	179.0		84.0		5.80	72.0	295.0	58.0	68.5	---	5.67	5.52	184.5	175.6
SEP 1992	62.0	102.0	106.0		119.0	171.5		86.0		5.80	69.5	300.0	59.0	66.0	---	5.3	5.3	189.0	185.9
OCT 1992	66.0	102.0	106.0		119.0	148.5		88.0		5.80	69.0	320.0	60.0	67.0	---	5.25	5.25	200.0	182.4
NOV 1992	72.0	103.5	106.0		111.0	150.0		93.0		5.72	68.5	310.0	42.0	62.0	---	5.3	5.17	178.0	181
DEC 1992	70.0	113.0	106.0		113.0	162.0		93.0		5.80	70.0	315.0	45.0	63.0	242.0	5.5	5.35	178.0	187.4
JAN 1993																			181.2
FEB 1993																			176.3
MAR 1993																			186.4
APR 1993	82.0	110.0	114.5		106.0	167.5		8.5		5.78	65.0	340.0	43.5	77.0	251.0	5.7	5.6	181.0	185.8
MAY 1993	83.0	106.0	110.0		111.0	177.5		83.5		5.75		320.0	43.5	72.0	246.0	5.725	5.57	179.0	191.8
JUN 1993	83.0	103.5	110.0		114.0	194.0		85.5.		5.58	70.0	320.0	55.0	78.5	235.0	5.37	5.52	186.0	203.6
JUL 1993	81.0	103.5	110.0		111.0	189.5		88.5		5.65	63.5	325.0	51.0	77.0	260.0	5.72	5.57	189.0	226.3
AUG 1993	83.0	103.5	110.0		117.5	201.0		84.5		5.57		365.0	49.5	78.5	292.0	5.97	5.82	201.0	209.4
SEP 1993	85.5	103.5	108.5		110.0	183.5		85.5		5.47	81.5	360.0	47.5	72.0	256.0	5.8	5.65	196.5	193.3
OCT 1993	88.5	103.5	107.0		110.5	188.5		94.5		5.65	79.0	345.0	51.5	72.0	247.0	5.65	5.65	194.5	192.7
NOV 1993	87.0	103.0	107.0		114.5	169.5		95.5		5.95	76.0	345.0	47.0	72.0	247.5	6.07	6.07	175.0	205.9
DEC 1993	90.0	108.0	107.0		123.0	184.0		110.5		6.30	83.0	360.0	69.5	77.0	262.0	6.72	6.57	185.5	203.8
JAN 1994	91.5	110.0	120.0		133.0	185.0		106.0		6.35	90.0	365.0	70.0	81.0	262.0	6.97	6.82	177.5	195.1
FEB 1994	94.0	110.0	132.0		135.0	195.5		123.5		6.25	122.5	345.0	71.5	94.5	248.0	6.77	6.62	174.0	192.8
MAR 1994	92.0	110.0	135.0		135.0	197.0		125.0		6.17	112.5	340.0	73.0	92.0	248.5	6.82	6.67	181.0	193.7
APR 1994	90.5	119.0	125.0		132.0	199.0		97.0		5.77	89.5	330.0	82.0	94.0	245.0	6.52	6.37	180.5	190.3
MAY 1994	89.0	118.5	131.5		135.0	184.0		96.0		5.90	83.5	310.0	81.0	93.5	237.0	6.42	6.32	179.0	202.6
JUN 1994	81.0	119.5	131.5		126.0	182.0		104.0		6.10	91.5	305.0	79.0	95.5	249.0	5.95	6.77	171.0	191.6
JUL 1994	83.5	123.5	129.0		119.0	179.5		111.5		5.77	109.0	302.0	83.0	91.5	240.0	5.9	5.82	170.5	177.3
AUG 1994	97.0	124.5	126.0		116.0	175.0		98.0		5.65	96.0	300.0	92.0	91.0	212.0	5.77	5.62	177.0	173.2
SEP 1994	82.0	116.0	123.0		113.5	184.5		102.0		5.88	83.0	290.0	85.0	81.5	215.0	5.65	5.77	184.5	161.6
OCT 1994	87.0	123.5	126.0		115.0	176.5		100.0		5.90	76.0	270.0	84.0	87.5	222.0	5.42	5.42	189.0	160.8
NOV 1994	87.0	120.5	125.5		117.0	164.0		89..5		6.05	71.0	275.0	69.0	88.5	223.0	5.37	5.37	164.0	156.6
DEC 1994	91.5	120.5	121.5		122.5	162.0		92.0		6.20	81.0	285.0	68.5	89.0	217.0	5.72	5.57	155.5	153.2
JAN 1995	93.0	114.0	123.0		127.5	169.0		100.5		5.96	85.5	285.0	67.5	86.5	213.0	5.87	5.72	152.0	156.2
FEB 1995	91.5	117.5	130.5		122.0	150.5		90.5		6.15	59.0	270.0	51.5	79.5	217.0	5.92	5.77	143.5	153.2
MAR 1995	90.0	117.5	130.5		122.0	148.5		92.0		6.15	60.0	265.0	42.5	76.5	215.0	6.02	5.87	142.5	167.4
APR 1995	89.5	115.0	124.0		118.5	143.5		99.0		6.12	74.5	260.0	39.5	73.5	217.0	6.27	6.12	139.0	161.9
MAY 1995	94.0	108.0	123.5		120.0	148.5		91.5		6.65	73.5	245.0	37.5	70.0	205.0	6.37	6.23	136.0	170.2
JUN 1995	96.5	109.0	UNQ		122.0	162.5		94.0		7.00	78.0	250.0	61.0	70.0	205.0	6.57	6.42	142.0	169.4
JUL 1995	106.0	109.0	UNQ		131.5	175.5		95.5		7.00	76.0	260.0	88.5	70.0	194.0	6.9	6.75	161.5	178.4
AUG 1995	110.0	117.0	UNQ		142.0	200.0		103.5		7.12	87.0	270.0	87.5	70.0	186.0	6.77	6.62	163.0	183.2
SEP 1995	104.0	117.0	UNQ		130.0	212.0		109.5		6.72	92.0	285.0	88.0	71.5	189.0	6.90	6.97	166.0	192.7
OCT 1995	110.0	124.0	121.0		140.5	199.0		114.0		7.85	101.5	315.0	87.5	79.5	214.0	7.00	7.10	200.0	208.3
NOV 1995	110.0	124.0	121.0		151.5	187.5		106.5		8.20	106.5	350.0	75.0	87.5	260.0	7.62	7.67	187.00	211.8

Table 4.13: Delivered HTV CGFA Prices ($/ton)

California Grain & Feed Market Review News

10-Day Shipment Bulk - Terms: Net Cash - Avg Bid/Ask Blank = N/A or UNQ

	Almond Hulls Whole Del LA	Beet Pulp Shreds FOB Plant	Beet Pulp Pellets FOB	Canola Meal Pellets UP/FOB	Corn Hominy 4% UP N/C	Cotton seed Whole FOB (Cor No)	Distiller's Dry Grain DLVD Rail	Millrun FOB N/C	Soyhull Pellets UP	Barley (Tulare Market)	Rice Bran (fob plant)	Corn Gluten Meal	Cotton-seed Hulls	Safflower Meal	Meat & Bone Meal	Corn Tulare Mrkt (Truck)	Corn Tulare Mrkt (Rail)	Cotton-seed Meal 41%	Soybean Meal 48%
Freight adjustment	**0**			**7**	**9**	**9**	**11**	**14**	**8**	**14**						**2.5**		**-9**	**33**
JAN 1992	74.5				137	142.5		112		133.7						121.9		165.5	208.8
FEB 1992	70				147	144		125.5		137.6						128.1		166.5	207.1
MAR 1992	68				142	161		117		137.4						128.9		157.5	211.7
APR 1993					141	160		99		139						125.9		158.5	205.9
MAY 1992	65				140.5	165		113		135.6						124.9		159	216.2
JUN 1992	63				137	162		105.5		136						127.1		163	213.6
JUL 1992	66				137	184		112.5		138.6						127.1		169	207.4
AUG 1992	68				132	188		98		130						115.9		175.5	208.6
SEP 1992	62				128	180.5		100		130						108.5		180	218.9
OCT 1992	66				128	157.5		102		130						107.5		191	215.4
NOV 1992	72				120	159		107		128.4						108.5		169	214
DEC 1992	70				122	171		107		130						112.5		169	220.4
JAN 1993										14								-9	214.2
FEB 1993										14								-9	209.3
MAR 1993										14								-9	219.4
APR 1993	82				115	176.5				129.6						117		172	218.8
MAY 1993	83				120	186.5		97.5		129						117		170	224.8
JUN 1993	83				123	203				125.5						109.9		177	236.6
JUL 1993	81				120	198.5		102.5		127						116.9		180	259.3

AUG 1993	83				126.5	210		98.5		125.4						121.9		192	242.4
SEP 1993	85.5				119	192.5		99.5		123.4						118.5		187.5	226.3
OCT 1993	88.5				119.5	197.5		108.5		127						115.5		185.5	225.7
NOV 1993	87				123.5	178.5		109.5		133						123.9		166	238.9
DEC 1993	90				132	193		124.5		140						136.9		176.5	236.8
JAN 1994	91.5				142	194		120		141						141.9		168.5	228.1
FEB 1994	94				144	204.5		137.5		139						137.9		165	225.8
MAR 1994	92				144	206		139		137.4						138.9		172	226.7
APR 1994	90.5				141	208		111		129.4						132.9		171.5	223.3
MAY 1994	89				144	193		110		132						130.9		170	235.6
JUN 1994	81				135	191		118		136						121.5		162	224.6
JUL 1994	83.5				128	188.5		125.5		129.4						120.5		161.5	210.3
AUG 1994	97				125	184		112		127						117.9		168	206.2
SEP 1994	82				122.5	193.5		116		131.6						115.5		175.5	194.6
OCT 1994	87				124	185.5		114		132						110.9		180	193.8
NOV 1994	87				126	173				135						109.9		155	189.6
DEC 1994	91.5				131.5	171		106		138						116.9		146.5	186.2
JAN 1995	93				136.5	178		114.5		133.2						119.9		143	189.2
FEB 1995	91.5				131	159.5		104.5		137						120.9		134.5	186.2
MAR 1995	90				131	157.5		106		137						122.9		133.5	200.4
APR 1995	89.5				127.5	152.5		113		136.4						127.9		130	194.9
MAY 1995	94				129	157.5		105.5		147						129.9		127	203.2
JUN 1995	96.5				131	171.5		108		154						133.9		133	202.4
JUL 1995	106				140.5	184.5		109.5		154						140.5		152.5	211.4
AUG 1995	110				151	209		117.5		156.4						137.9		154	216.2
SEP 1995	104				139	221		123.5		148.4						140.5		157	225.7
OCT 1995	110				149.5	208		128		171						142.5		191	241.3
NOV 1995	110				160.5	196.5		120.5		178						154.9		178	244.8
DEC 1995	108.5				164.5	213		156.5		182.4						156.5		191	266.2

Table 4.14: Delivered HTV CGFA Prices 5-year Ma ($/ton)

	Almond hulls	Canola meal	Hominy	Cottonseed	DDG	Millrun	Barley	Corn	Cottonseed meal	Soyhull pellets	Soybean meal
JAN 1997	91		142	189		121	140	133	166		228
FEB 1997	92		142	190		122	140	133	166		229
MAR 1997	92		142	191		122	140	133	167		231
APR 1997	93		142	192		122	140	133	168		233
MAY 1997	94		142	193		123	140	133	168		235
JUN 1997	95		142	194		123	141	134	169		236
JUL 1997	96		142	195		124	141	134	170		238
AUG 1997	97		142	196		124	141	134	171		239
SEP 1997	98		142	196		124	141	134	172		240
OCT 1997	98		142	196		124	141	134	172		241
NOV 1997	99		142	197		124	141	134	172		241
DEC 1997	99		142	198		125	142	135	173		242
JAN 1998	100		143	198		125	142	135	173		243
FEB 1998	100		142	198		125	144	135	176		243
MAR 1998	100		142	198		125	146	135	179		243
APR 1998	101		142	198		125	148	134	182		243
MAY 1998	101		142	198		125	148	135	182		242
JUN 1998	101		142	198		125	148	135	181		241
JUL 1998	102		142	198		125	148	135	180		241
AUG 1998	102		142	199		125	148	135	180		240
SEP 1998	103		142	199		125	147	135	180		238
OCT 1998	103		142	199		124	147	134	179		237
NOV 1998	103		141	199		124	147	134	178		236
DEC 1998	104		141	200		123	146	134	178		235
JAN 1999	104		141	200		123	146	133	177		234
FEB 1999	104		140	200		122	145	132	176		233
MAR 1999	104		139	200		122	145	132	175		232
APR 1999	104		139	200		121	144	131	174		231
MAY 1999	103		138	200		121	144	131	173		230
JUN 1999	103		138	200		120	144	131	173		229
JUL 1999	103		137	201		120	143	130	172		228
AUG 1999	103		137	201		119	143	130	172		227
SEP 1999	104		137	201		119	143	130	172		227
OCT 1999	104		136	201		118	143	129	171		227
NOV 1999	103		136	201		118	142	129	170		226
DEC 1999	103		135	201		117	142	129	169		226
JAN 2000	103		135	201		116	142	129	168		226
FEB 2000	103		135	200		116	141	128	168		226
MAR 2000	103		134	201		116	141	128	168		226
APR 2000	103		134	201		116	141	128	168		226
MAY 2000	103		134	201		115	141	128	168		227
JUN 2000	103		134	201		115	140	127	168		227
JUL 2000	103		133	201		115	140	127	169		227
AUG 2000	103		132	201		115	139	127	169		226
SEP 2000	103		131	201		114	138	126	169		226
OCT 2000	103		131	200		113	138	125	169		226
NOV 2000	102		130	199		112	137	125	168		225

Table 4.15: One-Half of Standard Deviation of Delivered HTV CGFA Prices ($/ton)

	Almond hulls	Canola meal	Hominy	Cottonseed	DDG	Millrun	Barley	Corn	Cottonseed meal	Soyhull pellets	Soybean meal
JAN 1997	8		11	12		10	18	12	24		14
FEB 1997	8		11	11		10	18	12	24		14
MAR 1997	8		11	11		10	18	12	24		15
APR 1997	8		11	11		10	18	12	24		16
MAY 1997	8		11	10		10	18	12	24		17
JUN 1997	8		11	11		10	18	12	24		18
JUL 1997	8		11	11		10	18	12	24		18
AUG 1997	8		11	11		10	18	12	24		18
SEP 1997	8		11	11		10	18	12	25		18
OCT 1997	7		11	11		10	18	12	25		18
NOV 1997	7		11	11		10	18	12	25		18
DEC 1997	7		11	11		9	18	12	25		18
JAN 1998	7		11	10		9	18	12	25		18
FEB 1998	6		10	10		9	16	12	22		18
MAR 1998	6		10	10		9	13	12	18		18
APR 1998	6		10	10		9	10	12	13		18
MAY 1998	6		10	10		9	10	11	13		18
JUN 1998	6		10	10		9	10	11	14		19
JUL 1998	6		10	10		9	10	11	14		19
AUG 1998	6		10	10		9	10	11	14		19
SEP 1998	6		10	10		9	11	12	14		20
OCT 1998	6		11	10		10	11	12	14		20
NOV 1998	6		11	10		10	11	12	14		21
DEC 1998	6		11	10		10	11	12	15		21
JAN 1999	6		11	10		10	12	12	15		21
FEB 1999	6		12	10		11	12	12	16		22
MAR 1999	6		12	10		11	12	12	16		23
APR 1999	6		12	10		11	12	12	17		23
MAY 1999	6		12	10		11	12	12	17		23
JUN 1999	6		12	10		11	12	13	17		24
JUL 1999	6		12	10		11	13	13	17		24
AUG 1999	6		12	10		11	13	13	17		24
SEP 1999	6		13	10		12	13	13	17		25
OCT 1999	6		13	10		12	13	13	18		25
NOV 1999	6		13	10		12	13	13	18		25
DEC 1999	7		13	10		12	13	13	18		25
JAN 2000	7		13	11		13	13	13	19		25
FEB 2000	7		13	11		13	13	14	19		25
MAR 2000	7		14	11		13	13	14	19		25
APR 2000	7		14	10		13	13	14	19		25
MAY 2000	7		14	10		13	13	14	19		25
JUN 2000	7		14	10		13	14	14	19		25
JUL 2000	7		14	10		13	14	14	19		25
AUG 2000	7		14	10		13	14	14	19		25
SEP 2000	7		14	10		13	14	14	19		25
OCT 2000	7		14	10		14	14	14	19		25
NOV 2000	7		15	10		14	14	14	19		25

Table 4.16: DLVD HTV CGFA Prices 5-Year Ma Minus One Half of Standard Deviation ($/ton)

	Almond hulls	Canola meal	Hominy	Cottonseed	DDG	Millrun	Barley	Corn	Cottonseed meal	Soyhull pellets	Soybean meal
JAN 1997	83		132	177		112	122	121	142		214
FEB 1997	84		132	179		112	122	121	143		215
MAR 1997	85		131	180		112	122	121	143		216
APR 1997	85		131	181		112	122	121	144		217
MAY 1997	86		131	182		113	122	121	145		218
JUN 1997	87		131	183		114	123	121	145		219
JUL 1997	88		131	184		114	123	121	146		220
AUG 1997	89		131	185		114	123	121	147		221
SEP 1997	90		131	185		114	123	122	147		222
OCT 1997	91		131	185		115	123	122	147		223
NOV 1997	92		131	186		115	123	122	148		223
DEC 1997	93		132	187		115	124	123	148		224
JAN 1998	94		132	188		116	124	123	148		225
FEB 1998	94		132	188		116	128	123	155		225
MAR 1998	94		132	188		116	132	123	161		225
APR 1998	94		132	188		115	137	123	169		224
MAY 1998	95		132	188		115	137	123	168		224
JUN 1998	95		132	188		116	137	123	167		223
JUL 1998	96		132	188		116	137	123	166		222
AUG 1998	96		132	188		116	137	123	166		220
SEP 1998	97		132	189		115	137	123	165		219
OCT 1998	97		131	189		115	136	122	165		217
NOV 1998	98		130	189		114	136	122	164		216
DEC 1998	98		130	189		113	135	122	163		214
JAN 1999	98		129	190		112	134	121	162		213
FEB 1999	98		128	190		112	134	120	160		211
MAR 1999	98		128	190		111	133	120	159		210
APR 1999	98		127	190		110	132	119	158		208
MAY 1999	97		126	190		110	132	119	156		207
JUN 1999	97		126	190		109	131	118	156		205
JUL 1999	97		125	191		109	131	118	155		204
AUG 1999	97		125	191		108	131	117	155		203
SEP 1999	97		124	191		107	130	117	154		202
OCT 1999	97		123	190		106	130	116	153		202
NOV 1999	97		123	190		105	129	116	152		202
DEC 1999	97		122	190		105	129	116	150		201
JAN 2000	96		121	190		104	129	115	150		201
FEB 2000	96		121	190		103	128	115	149		201
MAR 2000	96		121	190		103	128	114	149		202
APR 2000	96		121	190		103	127	114	149		202
MAY 2000	96		120	191		102	127	114	149		202
JUN 2000	96		120	191		102	127	114	149		202
JUL 2000	96		119	191		102	126	113	150		202
AUG 2000	96		118	191		102	126	113	150		201
SEP 2000	96		117	191		101	125	112	150		201
OCT 2000	96		116	190		100	124	112	150		201
NOV 2000	96		115	189		98	123	111	150		200

Table 4.17: Spot and Forward Prices on 1st of Month ($/ton)

	Rolled corn	Rolled barley	Soybean meal	Canola meal	Cottonseed	Cottonseed hulls	Ground pima	Soyhull pellets	DDG	Hominy	Corn germ meal	Mill run	Corn gluten feed	Beet pulp shreds	Beet pulp pellets	Almond hulls	Cottonseed meal	Rice Bran
Aug 1999-spot	106	107	175	140	178	na	156	90	113	100	100	na	93	117	na		na	na
Aug 1999-3 month	107	110	176	138	170	na	150	91	113	102	100	na	93	117	na	57	na	na
Aug 1999-clock 1	114	119	184	138	163	na	143	92	113	110	104	na	94	117	na	60	na	na
Aug 1999-clock 2	118	123																
Sep 1999-spot	104	109	170	138	173		151	87		98			100	115		57	154	
Sep 1999-3 month	104	111	171	132	160	71	137	86	115	102	105		100	115		57	135	
Sep 1999-clock 1	111	119	179	133	161		135	85	115	107	107		100			63		
Sep 1999-clock 2	116	121																
Oct 1999-spot	99	113	178	128	158	68	132	85	115	101	108		99	119		63	127	
Oct 1999-3 month	101	114	178	129	158	68	132	85	116	104	109		99	120		63	127	
Oct 1999-clock 1	106	119	183	134	167		141	85	120	104	110		101			69		
Oct 1999-clock 2	110	120																
Nov 1999-spot	100	115	179	123	157		133	90	118	104	113		102	118	118	64	125	
Nov 1999-3 month	102	117	177	123	162		138	90	118	104	113		102	118	118	68	127	
Nov 1999-clock 1	106	118	180	131	166		139	90	120	108	113		104		118	69		
Nov 1999-clock 2	113	126																
Dec 1999-spot	100	112	181	130	157		132	90	114	107	109			127	129		128	
Dec 1999-3 month	101	113	180	131	160		135	89	114	107	109			127	130		129	
Dec 1999-clock 1	105	116	179	133	168		137	90	114	110	109				131			
Dec 1999-clock 2	114	127	190	133														
Jan 2000-spot	100	112	177	136	168		139	89	122	122	106				122		125	
Jan 2000-3 month	101	113	177	135	168		140	89	120	117	106				122		125	

Jan 2000-clock 1	**103**	**115**	**178**	**134**	**170**		**145**	**90**	**116**	**110**	**106**				**125**			
Jan 2000-clock 2	**116**	**121**	**188**															
Feb 2000-spot	**106**	**114**	**186**	**148**	**165**			**86**	**119**	**118**	**103**				**124**		**135**	
Feb 2000-3 month	**107**	**115**	**188**	**147**	**165**			**86**	**119**	**115**	**102**				**124**		**135**	
Feb 2000-clock 1	**111**	**117**	**190**	**146**	**172**			**88**	**119**	**119**	**101**				**125**			
Feb 2000-clock 2	**120**	**123**	**203**	**146**							**106**							
Mar 2000-spot	**111**	**116**	**195**	**144**	**164**			**87**	**119**	**117**	**100**				**129**	**83**		
Mar 2000-3 month	**112**	**117**	**195**	**143**	**164**			**88**	**119**	**116**	**99**				**129**	**83**		
Mar 2000-clock 1	**112**	**118**	**197**	**141**	**170**			**89**	**124**	**112**	**99**					**85**		
Mar 2000-clock 2	**121**	**123**	**203**	**151**														
Apr 2000-spot	**116**	**119**	**202**	**132**	**166**		**151**	**92**	**116**	**116**	**103**			**127**		**100**		
Apr 2000-3 month	**119**	**120**	**203**	**132**	**166**			**92**	**116**	**114**	**103**			**127**		**100**		
Apr 2000-clock 1	**119**	**119**	**204**	**132**	**168**			**92**	**118**	**114**	**102**			**127**		**100**		
Apr 2000-clock 2	**128**	**128**	**213**	**152**	**162**			**91**	**120**	**121**	**110**					**88**		
May 2000-spot	**117**	**121**	**206**	**140**	**174**			**96**	**130**	**112**	**98**			**128**		**91**		
May 2000-3 month	**118**	**122**	**206**	**140**	**174**			**96**	**131**	**111**	**98**			**128**		**92**		
May 2000-clock 1	**119**	**122**	**206**	**140**	**174**			**96**	**134**	**111**	**98**			**128**		**92**		
May 2000-clock 2	**126**	**127**	**213**	**150**	**164**			**91**	**124**	**122**	**111**					**88**		
June 2000-spot	**113**	**123**	**208**	**139**	**175**			**91**	**127**	**106**	**95**		**94**	**128**		**88**		**87**
June 2000-3 month	**112**	**122**	**208**	**139**	**175**			**91**	**127**	**106**	**95**		**94**	**128**		**84**		
June 2000-clock 1	**112**	**122**	**208**	**139**	**175**			**91**	**127**	**106**	**95**		**94**	**128**		**82**		
June 2000-clock 2	**123**	**128**	**206**	**139**	**165**				**128**	**120**	**103**		**101**			**77**		
Jly 2000-spot	**99**	**117**	**199**	**137**	**185**			**89**	**125**	**96**	**96**		**92**	**128**		**91**		**88**
Jly 2000-3 month	**99**	**116**	**196**	**137**	**185**			**89**	**125**	**96**	**96**		**92**	**128**		**82**		**88**
Jly 2000-clock 1	**99**	**116**	**196**	**137**	**185**			**89**	**125**	**96**	**96**		**92**	**128**		**82**		**88**
Jly 2000-clock 2	**106**	**117**	**188**	**132**	**166**		**160**	**91**	**127**	**110**	**100**		**99**			**77**		
Aug 2000-spot	**91**	**109**	**182**	**147**	**174**		**160**	**84**	**114**	**95**	**96**		**93**	**128**		**75**		**91**
Aug 2000-3 month	**93**	**111**	**182**	**140**	**166**			**85**	**114**	**101**	**96**		**95**	**128**		**77**		

Aug 2000-clock 1	**102**	**115**	**181**	**132**	**156**		**157**	**85**	**118**	**108**	**98**		**102**	**128**		**77**		
Aug 2000-clock 2	**102**	**115**	**181**	**132**	**156**		**157**	**85**	**118**	**108**	**98**		**102**	**128**		**77**		
Sep 2000-spot	**97**	**108**	**205**	**144**	**168**		**160**	**82**	**119**	**92**	**102**		**93**	**128**		**89**	**148**	
Sep 2000-3 month	**98**	**112**	**203**	**143**	**150**		**152**	**84**	**119**	**102**	**104**		**99**	**128**		**89**		
Sep 2000-clock 1	**104**	**115**	**204**	**146**	**157**		**157**	**85**	**121**	**105**	**103**		**102**			**89**		
Sep 2000-clock 2																		
Oct 2000-spot	**100**	**108**	**209**	**144**	**170**			**96**	**116**	**93**	**108**		**93**	**128**	**130**	**96**		**91**
Oct 2000-3 month	**101**	**111**	**207**	**142**	**155**		**153**	**92**	**118**	**96**	**107**		**93**	**128**		**96**		
Oct 2000-clock 1	**103**	**114**	**208**	**144**	**160**		**158**	**97**	**116**	**105**	**109**		**102**			**96**		

Table 4.18: Weekly Spot Prices ($/lb)

	Alfalfa Early bloom	Almond Hulls	Barley grain	Beet Pulp	Canola Meal	Corn grain, flaked	Cottonseed, whole fuzzy	Cottonseed Meal 41%	Dried Distillers Grain, corn	Fat	Hominy	Molasses	Rice Bran	Soybean Hulls, pelleted	Soybean Meal 48%	Wheat Middlings
Aug 99-1	0.06	0.00	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Aug 99-2	0.06	0.00	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Aug 99-3	0.06	0.00	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Aug 99-4	0.06	0.00	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Aug 99-5	0.06	0.00	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Sep 99-1	0.06	0.03	0.05	0.06	0.07	0.05	0.09	0.08	0.00	0.14	0.05	0.05	0.00	0.04	0.09	0.00
Sep 99-2	0.06	0.03	0.05	0.06	0.07	0.05	0.09	0.08	0.00	0.14	0.05	0.05	0.00	0.04	0.09	0.00
Sep 99-3	0.06	0.03	0.05	0.06	0.07	0.05	0.09	0.08	0.00	0.14	0.05	0.05	0.00	0.04	0.09	0.00
Sep 99-4	0.06	0.03	0.05	0.06	0.07	0.05	0.09	0.08	0.00	0.14	0.05	0.05	0.00	0.04	0.09	0.00
Oct 99-1	0.06	0.03	0.06	0.06	0.06	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.04	0.09	0.00
Oct 99-2	0.06	0.03	0.06	0.06	0.06	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.04	0.09	0.00
Oct 99-3	0.06	0.03	0.06	0.06	0.06	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.04	0.09	0.00
Oct 99-4	0.06	0.03	0.06	0.06	0.06	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.04	0.09	0.00
Oct 99-5	0.06	0.03	0.06	0.06	0.06	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.04	0.09	0.00
Nov 99-1	0.06	0.03	0.06	0.06	0.06	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Nov 99-2	0.06	0.03	0.06	0.06	0.06	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Nov 99-3	0.06	0.03	0.06	0.06	0.06	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Nov 99-4	0.06	0.03	0.06	0.06	0.06	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Dec 99-1	0.06	0.00	0.06	0.06	0.07	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Dec 99-2	0.06	0.00	0.06	0.06	0.07	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Dec 99-3	0.06	0.00	0.06	0.06	0.07	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Dec 99-4	0.06	0.00	0.06	0.06	0.07	0.05	0.08	0.06	0.06	0.14	0.05	0.05	0.00	0.05	0.09	0.00
Jan 00-1	0.07	0.00	0.06	0.00	0.07	0.05	0.08	0.06	0.06	0.14	0.06	0.05	0.00	0.04	0.09	0.00
Jan 00-2	0.07	0.00	0.06	0.00	0.07	0.05	0.08	0.06	0.06	0.14	0.06	0.05	0.00	0.04	0.09	0.00
Jan 00-3	0.07	0.00	0.06	0.00	0.07	0.05	0.08	0.06	0.06	0.14	0.06	0.05	0.00	0.04	0.09	0.00
Jan 00-4	0.07	0.00	0.06	0.00	0.07	0.05	0.08	0.06	0.06	0.14	0.06	0.05	0.00	0.04	0.09	0.00
Jan 00-5	0.07	0.00	0.06	0.00	0.07	0.05	0.08	0.06	0.06	0.14	0.06	0.05	0.00	0.04	0.09	0.00
Feb 00-1	0.07	0.00	0.06	0.00	0.07	0.05	0.08	0.07	0.06	0.14	0.06	0.05	0.00	0.04	0.09	0.00
Feb 00-2	0.07	0.00	0.06	0.00	0.07	0.05	0.08	0.07	0.06	0.14	0.06	0.05	0.00	0.04	0.09	0.00

Feb 00-3	0.07	0.00	0.06	0.00	0.07	0.05	0.08	0.07	0.06	0.14	0.06	0.05	0.00	0.04	0.09	0.00
Feb 00-4	0.07	0.00	0.06	0.00	0.07	0.05	0.08	0.07	0.06	0.14	0.06	0.05	0.00	0.04	0.09	0.00
Mar 00-1	0.06	0.04	0.06	0.00	0.07	0.06	0.08	0.00	0.06	0.14	0.06	0.05	0.00	0.04	0.10	0.00
Mar 00-2	0.06	0.04	0.06	0.00	0.07	0.06	0.08	0.00	0.06	0.14	0.06	0.05	0.00	0.04	0.10	0.00
Mar 00-3	0.06	0.04	0.06	0.00	0.07	0.06	0.08	0.00	0.06	0.14	0.06	0.05	0.00	0.04	0.10	0.00
Mar 00-4	0.06	0.04	0.06	0.00	0.07	0.06	0.08	0.00	0.06	0.14	0.06	0.05	0.00	0.04	0.10	0.00
Apr 00-1	0.06	0.05	0.06	0.06	0.07	0.06	0.08	0.00	0.06	0.14	0.06	0.05	0.00	0.05	0.10	0.00
Apr 00-2	0.06	0.05	0.06	0.06	0.07	0.06	0.08	0.00	0.06	0.14	0.06	0.05	0.00	0.05	0.10	0.00
Apr 00-3	0.06	0.05	0.06	0.06	0.07	0.06	0.08	0.00	0.06	0.14	0.06	0.05	0.00	0.05	0.10	0.00
Apr 00-4	0.06	0.05	0.06	0.06	0.07	0.06	0.08	0.00	0.06	0.14	0.06	0.05	0.00	0.05	0.10	0.00
May 00-1	0.06	0.05	0.06	0.06	0.07	0.06	0.09	0.00	0.07	0.14	0.06	0.05	0.00	0.05	0.10	0.00
May 00-2	0.06	0.05	0.06	0.06	0.07	0.06	0.09	0.00	0.07	0.14	0.06	0.05	0.00	0.05	0.10	0.00
May 00-3	0.06	0.05	0.06	0.06	0.07	0.06	0.09	0.00	0.07	0.14	0.06	0.05	0.00	0.05	0.10	0.00
May 00-4	0.06	0.05	0.06	0.06	0.07	0.06	0.09	0.00	0.07	0.14	0.06	0.05	0.00	0.05	0.10	0.00
May 00-5	0.06	0.05	0.06	0.06	0.07	0.06	0.09	0.00	0.07	0.14	0.06	0.05	0.00	0.05	0.10	0.00
Jun 00-1	0.06	0.04	0.06	0.06	0.07	0.06	0.09	0.00	0.06	0.14	0.05	0.05	0.04	0.05	0.10	0.00
Jun 00-2	0.06	0.04	0.06	0.06	0.07	0.06	0.09	0.00	0.06	0.14	0.05	0.05	0.04	0.05	0.10	0.00
Jun 00-3	0.06	0.04	0.06	0.06	0.07	0.06	0.09	0.00	0.06	0.14	0.05	0.05	0.04	0.05	0.10	0.00
Jun 00-4	0.06	0.04	0.06	0.06	0.07	0.06	0.09	0.00	0.06	0.14	0.05	0.05	0.04	0.05	0.10	0.00
Jly 00-1	0.06	0.05	0.06	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.04	0.04	0.10	0.00
Jly 00-2	0.06	0.05	0.06	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.04	0.04	0.10	0.00
Jly 00-3	0.06	0.05	0.06	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.04	0.04	0.10	0.00
Jly 00-4	0.06	0.05	0.06	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.04	0.04	0.10	0.00
Aug 00-1	0.06	0.04	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.05	0.04	0.09	0.00
Aug 00-2	0.06	0.04	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.05	0.04	0.09	0.00
Aug 00-3	0.06	0.04	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.05	0.04	0.09	0.00
Aug 00-4	0.06	0.04	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.05	0.04	0.09	0.00
Aug 00-5	0.06	0.04	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.05	0.04	0.09	0.00
Sep 00-1	0.06	0.04	0.05	0.06	0.07	0.05	0.08	0.07	0.06	0.14	0.05	0.05	0.00	0.04	0.10	0.00
Sep 00-2	0.06	0.04	0.05	0.06	0.07	0.05	0.08	0.07	0.06	0.14	0.05	0.05	0.00	0.04	0.10	0.00
Sep 00-3	0.06	0.04	0.05	0.06	0.07	0.05	0.08	0.07	0.06	0.14	0.05	0.05	0.00	0.04	0.10	0.00
Sep 00-4	0.06	0.04	0.05	0.06	0.07	0.05	0.08	0.07	0.06	0.14	0.05	0.05	0.00	0.04	0.10	0.00
Oct 00-1	0.06	0.05	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.05	0.05	0.10	0.00
Oct 00-2	0.06	0.05	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.05	0.05	0.10	0.00
Oct 00-3	0.06	0.05	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.05	0.05	0.10	0.00

Oct 00-4	0.06	0.05	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.05	0.05	0.10	0.00
Oct 00-5	0.06	0.05	0.05	0.06	0.07	0.05	0.09	0.00	0.06	0.14	0.05	0.05	0.05	0.05	0.10	0.00

Table 4.19: Monthly DLVD HTV Hay Prices ($/ton)

Hay delivered into Hanford, Visalia, Tulare

	Supreme	Premium	Good	Fair
ADF, 100% DM	<.27	.27-.29	.29-.32	.32-.35
TDN, 90% DM	55.9>	54.5-55.9	52.5-54.5	50.5-52.5
Jan-85		122.50	117.50	112.50
Feb-85		121.75	115.25	110.00
Mar-85		135.38	121.25	110.25
Apr-85		123.80	116.80	105.00
May-85		123.38	115.25	107.50
Jun-85		112.62	107.12	99.38
Jul-85		103.75	92.90	86.90
Aug-85			92.50	84.50
Sep-85		105.88	96.50	86.90
Oct-85		109.62	98.12	88.12
Nov-85		110.00	98.75	90.62
Dec-85			106.38	90.38
Jan-86			108.00	92.50
Feb-86		120.00	108.75	93.12
Mar-86		120.60	107.90	90.50
Apr-86			102.12	80.00
May-86		113.38	102.50	87.50
Jun-86			96.00	85.00
Jul-86			83.13	73.13
Aug-86		87.50	76.88	66.88
Sep-86		91.00	80.00	69.00
Oct-86		97.50	82.50	69.38
Nov-86		105.83	91.50	73.75
Dec-86		113.00	99.50	77.50
Jan-87		116.63	104.38	84.38
Feb-87			105.00	85.00
Mar-87		119.70	107.10	87.50
Apr-87		116.25	104.50	87.50
May-87		117.75	105.63	86.88
Jun-87			102.60	87.50
Jul-87			92.50	81.00
Aug-87			95.50	84.80
Sep-87		103.13	97.50	88.75
Oct-87		106.25	98.75	88.75
Nov-87		109.50	99.50	90.00
Dec-87		118.13	107.50	88.50
Jan-88		119.38	109.63	90.00
Feb-88		117.00	103.00	86.00
Mar-88		119.25	100.00	87.50
Apr-88		122.50	105.00	90.50
May-88		126.00	119.38	96.67
Jun-88		118.00	113.13	98.13
Jul-88		110.17	101.13	94.38
Aug-88		105.40	97.50	93.00
Sep-88		109.75	104.25	97.00
Oct-88		117.90	111.80	103.20
Nov-88		118.75	113.75	105.62
Dec-88		119.17	112.50	105.00
Jan-89		137.50	125.00	116.75
Feb-89		141.62	131.62	124.37
Mar-89		148.50	136.00	
Apr-89		142.00	130.00	
May-89		134.50	123.75	110.63
Jun-89		127.00	112.00	102.50
Jul-89		112.50	100.63	
Aug-89		117.50	105.00	
Sep-89		125.00	112.50	
Oct-89		133.13	118.13	105.00

	Supreme	Premium	Good	Fair
ADF, 100%	<.27	.27-.29	.29-.32	.32-.35
TDN, 90%	55.9>	54.5-55.9	52.5-54.5	50.5-52.5
Nov-89		140.00	120.00	105.00
Dec-89		140.00	120.00	105.00
Jan-90		142.50	124.38	
Feb-90		148.25	137.50	125.00
Mar-90		151.50	137.50	126.67
Apr-90		143.13		
May-90		143.50	137.50	
Jun-90		139.33	126.33	
Jul-90		119.17	115.63	107.50
Aug-90			113.50	106.00
Sep-90		135.83	115.00	105.00
Oct-90		136.63		
Nov-90		133.70		
Dec-90		137.50		
Jan-91				
Feb-91		132.63	123.00	
Mar-91		145.00	131.25	
Apr-91		135.00	122.50	
May-91		122.50	115.63	
Jun-91		115.00	100.63	
Jul-91			92.50	80.00
Aug-91				77.20
Sep-91				76.00
Oct-91		100.00	85.00	75.00
Nov-91		99.70		74.00
Dec-91		92.50		70.00
Jan-92		106.80	85.00	72.25
Feb-92				70.88
Mar-92		103.86	82.17	68.88
Apr-92		109.00	92.00	68.75
May-92		123.90	106.17	70.00
Jun-92		119.88	96.00	69.38
Jul-92		108.75	87.50	70.00
Aug-92			81.00	69.00
Sep-92			95.00	75.00
Oct-92		114.00	92.00	77.90
Nov-92		116.00	98.75	80.00
Dec-92		135.67	99.50	87.67
Jan-93		133.75	101.67	
Feb-93		133.50	111.25	
Mar-93		130.75	102.50	94.50
Apr-93		137.60	126.75	105.83
May-93		143.88	131.88	110.38
Jun-93		136.75	122.50	110.00
Jul-93		131.67	118.00	105.50
Aug-93		133.30	119.50	106.25
Sep-93		136.00	124.00	112.50
Oct-93		139.80		112.50
Nov-93		146.25		115.00
Dec-93		148.75	128.75	
Jan-94		150.62	135.62	125.00
Feb-94		153.12	142.50	132.50
Mar-94		159.37	145.62	132.50
Apr-94		152.50	141.50	125.50
May-94		153..12	135.62	118.12
Jun-94		150.62	133.75	115.62
Jul-94		142.50	127.00	114.00

Table 4.20: Prices Used

	Rolled corn	Rolled corn	Rolled corn	Rolled corn	Rolled corn	Rolled corn	Rolled barley	Rolled barley	Rolled barley	Rolled barley	Rolled barley	Rolled barley	Cottonseed	Cottonseed	Cottonseed	Cottonseed	Cottonseed	Cottonseed
	5 yr ma - 1/2 SD	Spot	3 month	Clock 1	Clock 2	Price used	5 yr ma - 1/2 SD	Spot	3 month	Clock 1	Clock 2	Price used	5 yr ma - 1/2 SD	Spot	3 month	Clock 1	Clock 2	Price used
Aug-99	117	106	107	114	118	106	131	107	110	119	123	107	191	178	170	163		178
Sep-99	117	104	104	111	116	104	130	109	111	119	121	109	191	173	160	161		173
Oct-99	116	99	101	106	110	114	130	113	114	119	120	119	190	158	158	167		163
Nov-99	116	100	102	106	113	114	129	115	117	118	126	119	190	157	162	166		163
Dec-99	116	100	101	105	114	114	129	112	113	116	127	119	190	157	160	168		163
Jan-00	115	100	101	103	116	114	129	112	113	115	121	119	190	168	168	170		163
Feb-00	115	106	107	111	120	114	128	114	115	117	123	119	190	165	165	172		163
Mar-00	114	111	112	112	121	114	128	116	117	118	123	119	190	164	164	170		163
Apr-00	114	116	119	119	128	114	127	119	120	119	128	119	190	166	166	168	162	163
May-00	114	117	118	119	126	114	127	121	122	122	127	119	191	174	174	174	164	163
Jun-00	114	113	112	112	123	114	127	123	122	122	128	119	191	175	175	175	165	163
Jul-00	113	99	99	99	106	114	126	117	116	116	117	119	191	185	185	185	166	163
Aug-00	113	91	93	102	102	114	126	109	111	115	115	119	191	174	166	156	156	163
Sep-00	112	97	98	104		114	125	108	112	115		119	191	168	150	157		163
Oct-00	112	100	101	103		116	124	108	111	114		123	190	170	155	160		162
Nov-00	111	107	108	111	129	116	123	117	117	118	136	123	189	158	158	163		162
Dec-00	110	108	110	112	130	116	122	127	126	125	143	123	188	162	165	168		162
Jan-01	109	115	113	116	134	116	121	127	126	127	131	123	187	162	168	168	164	162
Feb-01	109	106	106	109	123	116	121	125	125	126	129	123	186	168	168	166	160	162
Mar-01	109	114	112	112	124	116	120	121	123	122	125	123	185	168	166	166	158	162
Apr-01	108	106	106	107	119	116	120	120	121	122	125	123	184	160	161	161	156	162
May-01	108	103	103	103	113	116	119	119	120	120	122	123	183	175	172	172	156	162
Jun-01	107	102	102	102	109	116	118	122	122	122	124	123	182	178	178	178		162
Jul-01	107	100	100	100	104	116	118	121	121	121	120	123	182	188	188	188		162

Aug-01	108	103	103	108		116	118	120	119	122		123	182	200	190	172		162
Sep-01	107	104	106	113		116	118	118	118	124		123	182	175	168	168		162
Oct-01	107	97	100	106		104	118	119	121	125		119	182	160	160	168		164
Nov-01	107	98	100	105		104	117	125	125	126		125	181	162	164	169		164
Dec-01	106	105	104	107		104	117	127	127	128		127	180	164	169	172		164
Jan-02	106	101	102	104	115	104	117	127	127	128		127	180	170	172	175		164
Feb-02	106	100	101	103	114	104	117	125	126	128		125	180	172	172	172	175	164
Mar-02	106	100	101	103	113	104	117	123	124	125	127	123	179	166	167	168	172	164
Apr-02	105	100	101	102	111	104	116	124	124	124	127	124	179	168	171	171	173	164
May-02	105	99	100	100	108	104	116	121	121	121	124	121	178	166	167	168	173	164
Jun-02	105	102	103	103	111	104	116	121	119	118	122	121	177	173	173	173	175	164
Jul-02	104	111	112	118		104	116	125	123	124		125	177	180	180	185		164
Aug-02	104	119	120	124		104	116	131	131	134		131	176	178	178	183		164
Sep-02	104	125	126	128		104	116	135	137	140		135	176	170	177	180		164
Oct-02	104	123	124	127		123	116	137	140	144		137	176	170	169	174		175
Nov-02	104	120	121	124		120	116	139	140	142		139	176	168	171	178		175
Dec-02	104	115	116	118		115	116	144	144	144		144	175	167	170	177		175
Jan-03	104	113	115	117		113	116	146	146	144		146	175	177	177	181		175
Feb-03	104	116	117	118	119	116	115	138	139	138	135	138	174	188	190	194	180	175
Mar-03	104	115	116	116	118	115	115	141	142	139	135	141	174	198	199	198	178	175
Apr-03	104	117	117	117	119	117	116	143	143	139	137	143	174	205	205	205	176	175
May-03	104	113	113	113	117	113	116	152	145	139	135	152	174	230	230	230	183	175
Jun-03	104	116	116	116	119	116	116	135	133	133	131	135	174	231	231	231	184	175
Jul-03	104	113	111	111	112	113	116	140	133	133	130	140	174	217	217	217	184	175
Aug-03	104	107	106	110		107	116	135	135	136		135	174	215	204	183		175
Sep-03	104	118	116	118		118	117	147	146	142		147	174	167	160	160		175
Oct-03	104	113	112	114		113	117	140	139	138		140	174	210	210	210		210
Nov-03	104	119	119	121		119	118	145	145	142		145	174	200	200	200		200
Dec-03	105	123	122	122		123	118	144	144	143		144	174	197	201	205		197
Jan-04	105	122	122	123	123	122	119	149	146	141		149	175	201	202	207	195	201
Feb-04	105	131	130	132	130	131	119	149	150	150		149	174	209	215	214	205	209
Mar-04	105	140	140	140	140	140	120	152	153	151		152	174	230	230	230	210	230

Apr-04	105	146	146	147	146	146	120	150	151	151		150	174	235	236	245	215	235
May-04	105	147	147	148	146	147	121	155	154	154	158	155	175	245	247	250	215	245
Jun-04	105	151	151	150	147	151	121	156	154	155	158	156	175	245	247	248	212	245
Jul-04	105	127	128	128	131	127	122	150	150	150	155	150	175	234	234	234	216	234
Aug-04	106	118	113	118		118	122	145	141	145		145	175	180	194	180		180
Sep-04	106	123	121	123		123	122	142	132	142		142	175	190	189	190		190
Oct-04	106	110	109	113	127	110	123	131	132	137		131	176	290	164	174		290
Nov-04	107	108	108	111	127	108	122	134	134	134		134	176	164	171	175		164
Dec-04	107	106	106	110	125	106	123	124	124	126		124	176	170	170	179		170

Table 4.21: Prices Used & Spot ($/ton)

	Rolled corn	Rolled corn	Rolled barley	Rolled barley	Cottonseed	Cottonseed	Hominy	Hominy	Mill run	Mill run	Almond hulls	Almond hulls	Cottonseed meal	Cottonseed meal	Canola meal	Canola meal
	Spot	Price used	Spot	Price used	Spot	Price used	Spot	Price used	Spot	Price used	Spot	Price used	Spot	Price used	Spot	Price used
Aug-99	106	106	107	107	178	178	100	100							140	140
Sep-99	104	104	109	109	173	173	98	98			57	57	154	154	138	138
Oct-99	99	114	113	119	158	163	101	110			63	63	127	127	128	128
Nov-99	100	114	115	119	157	163	104	110			64	64	125	127	123	123
Dec-99	100	114	112	119	157	163	107	110					128	127	130	130
Jan-00	100	114	112	119	168	163	122	110					125	125	136	136
Feb-00	106	114	114	119	165	163	118	110					135	125	148	148
Mar-00	111	114	116	119	164	163	117	110			83	85		125	144	144
Apr-00	116	114	119	119	166	163	116	110			100	85			132	132
May-00	117	114	121	119	174	163	112	110			91	85			140	140
Jun-00	113	114	123	119	175	163	106	110			88	85			139	139
Jul-00	99	114	117	119	185	163	96	110			91	85			137	137
Aug-00	91	114	109	119	174	163	95	110			75	85			147	147
Sep-00	97	114	108	119	168	163	92	110			89	85	148	148	144	144
Oct-00	100	116	108	123	170	162	93	121			96	88			144	144
Nov-00	107	116	117	123	158	162	102	121			96	88			144	144
Dec-00	108	116	127	123	162	162	102	121			88	88			164	164
Jan-01	115	116	127	123	162	162	112	121			92	88			176	176
Feb-01	106	116	125	123	168	162	109	121	103	103	94	88	176	176	158	158
Mar-01	114	116	121	123	168	162	101	121	80	89	94	88	186	186	162	162
Apr-01	106	116	120	123	160	162	103	121	76	89	93	88	184	184	164	164
May-01	103	116	119	123	175	162	100	121	89	89	95	88	184	184	169	169
Jun-01	102	116	122	123	178	162	106	121	92	89	95	88	184	184	169	169
Jul-01	100	116	121	123	188	162	109	121	77	89	95	88	184	184	174	174
Aug-01	103	116	120	123	200	162	111	121	85	89	85	88	184	184	169	169
Sep-01	104	116	118	123	175	162	111	121	90	89	85	88	165	165	154	154
Oct-01	97	104	119	119	160	164	111	108	90	91	94	85	165	165	156	156
Nov-01	98	104	125	125	162	164	105	108	96	91	94	85	152	152	160	160

Dec-01	105	104	127	127	164	164	109	108	96	91	94	85	149	149	155	155
Jan-02	101	104	127	127	170	164	112	108		91	94	85	144	144	150	150
Feb-02	100	104	125	125	172	164	112	108		91	0	85	143	143	152	152
Mar-02	100	104	123	123	166	164	113	108	101	91	0	85	0	0	159	159
Apr-02	100	104	124	124	168	164	113	108		91	0	85	135	135	161	161
May-02	99	104	121	121	166	164	109	108	84	91	0	85	145	145	162	162
Jun-02	102	104	121	121	173	164	103	108	83	91	0	85	139	139	162	162
Jul-02	111	104	125	125	180	164	106	108	103	91	0	85	137	137	167	167
Aug-02	119	104	131	131	178	164	106	108	93	91	0	85	142	142	164	164
Sep-02	125	104	135	135	170	164	130	108	90	91	0	85	152	152	159	159
Oct-02	123	123	137	137	170	175	134	134	108	108	0	85	152	152	153	153
Nov-02	120	120	139	139	168	175	122	122	98	98	83	85	148	148	149	149
Dec-02	115	115	144	144	167	175	121	121	96	96	85	85	148	148	150	150
Jan-03	113	113	146	146	177	175	125	125	97	97	88	85	144	144	159	159
Feb-03	116	116	138	138	188	175	126	126	94	94	88	85	143	143	0	0
Mar-03	115	115	141	141	198	175			97	97	87	85	144	144	167	167
Apr-03	117	117	143	143	205	175					85	85	145	145	159	159
May-03	113	113	152	152	230	175	128	128	101	101	87	85	157	157	158	158
Jun-03	116	116	135	135	231	175	125	125	98	98	86	85	0	0	160	160
Jul-03	113	113	140	140	217	175	123	123	101	101	84	85	0	0	158	158
Aug-03	107	107	135	135	215	175	119	119	91	91	100	85	164	164	147	147
Sep-03	118	118	147	147	167	175	116	116	87	87	83	85	167	167	162	162
Oct-03	113	113	140	140	210	210	117	117	92	92	84	85	167	167	161	161
Nov-03	119	119	145	145	200	200	115	115	98	98	86	85	207	207	204	204
Dec-03	123	123	144	144	197	197	116	116			92	85	193	193	194	194
Jan-04	122	122	149	149	201	201	122	122	113	113	93	93	207	207	219	219
Feb-04	131	131	149	149	209	209	132	132	121	121	93	93	194	194	216	216
Mar-04	140	140	152	152	230	230	137	137	111	111	95	95	217	217	224	224
Apr-04	146	146	150	150	235	235					97	97	219	219	229	229
May-04	147	147	155	155	245	245	157	157	146	146	106	106	218	218	214	214
Jun-04	151	151	156	156	245	245	159	159	130	130	103	103	214	214	205	205
Jul-04	127	127	150	150	234	234	159	159	112	112	110	110	209	209	194	194
Aug-04	118	118	145	145	180	180	129	129	105	105	95	95	163	163	156	156

Table 4.22: Prices Used & Spot ($/lb)

	Rolled corn Spot	Rolled corn Price used	Rolled barley Spot	Rolled barley Price used	Cottonseed Spot	Cottonseed Price used	Hominy Spot	Hominy Price used	Mill run Spot	Mill run Price used	Almond hulls Spot	Almond hulls Price used	Cottonseed meal Spot	Cottonseed meal Price used	Canola meal Spot	Canola meal Price used
Aug-99	0.053	0.053	0.0535	0.0535	0.089	0.089	0.05	0.05							0.07	0.07
Sep-99	0.052	0.052	0.0545	0.0545	0.0865	0.0865	0.049	0.049			0.0285	0.0285	0.077	0.077	0.069	0.069
Oct-99	0.0495	0.057	0.0565	0.0595	0.079	0.0815	0.0505	0.055			0.0315	0.0315	0.0635	0.0635	0.064	0.064
Nov-99	0.05	0.057	0.0575	0.0595	0.0785	0.0815	0.052	0.055			0.032	0.032	0.0625	0.0635	0.0615	0.0615
Dec-99	0.05	0.057	0.056	0.0595	0.0785	0.0815	0.0535	0.055					0.064	0.0635	0.065	0.065
Jan-00	0.05	0.057	0.056	0.0595	0.084	0.0815	0.061	0.055					0.0625	0.0625	0.068	0.068
Feb-00	0.053	0.057	0.057	0.0595	0.0825	0.0815	0.059	0.055					0.0675	0.0625	0.074	0.074
Mar-00	0.0555	0.057	0.058	0.0595	0.082	0.0815	0.0585	0.055			0.0415	0.0425			0.072	0.072
Apr-00	0.058	0.057	0.0595	0.0595	0.083	0.0815	0.058	0.055			0.05	0.0425			0.066	0.066
May-00	0.0585	0.057	0.0605	0.0595	0.087	0.0815	0.056	0.055			0.0455	0.0425			0.07	0.07
Jun-00	0.0565	0.057	0.0615	0.0595	0.0875	0.0815	0.053	0.055			0.044	0.0425			0.0695	0.0695
Jul-00	0.0495	0.057	0.0585	0.0595	0.0925	0.0815	0.048	0.055			0.0455	0.0425			0.0685	0.0685
Aug-00	0.0455	0.057	0.0545	0.0595	0.087	0.0815	0.0475	0.055			0.0375	0.0425			0.0735	0.0735
Sep-00	0.0485	0.057	0.054	0.0595	0.084	0.0815	0.046	0.055			0.0445	0.0425	0.074	0.074	0.072	0.072
Oct-00	0.05	0.058	0.054	0.0615	0.085	0.081	0.0465	0.0605			0.048	0.044			0.072	0.072
Nov-00	0.0535	0.058	0.0585	0.0615	0.079	0.081	0.051	0.0605			0.048	0.044			0.072	0.072
Dec-00	0.054	0.058	0.0635	0.0615	0.081	0.081	0.051	0.0605			0.044	0.044			0.082	0.082
Jan-01	0.0575	0.058	0.0635	0.0615	0.081	0.081	0.056	0.0605			0.046	0.044			0.088	0.088
Feb-01	0.053	0.058	0.0625	0.0615	0.084	0.081	0.0545	0.0605	0.0515	0.0515	0.047	0.044	0.088	0.088	0.079	0.079
Mar-01	0.057	0.058	0.0605	0.0615	0.084	0.081	0.0505	0.0605	0.04	0.0445	0.047	0.044	0.093	0.093	0.081	0.081
Apr-01	0.053	0.058	0.06	0.0615	0.08	0.081	0.0515	0.0605	0.038	0.0445	0.0465	0.044	0.092	0.092	0.082	0.082
May-01	0.0515	0.058	0.0595	0.0615	0.0875	0.081	0.05	0.0605	0.0445	0.0445	0.0475	0.044	0.092	0.092	0.0845	0.0845
Jun-01	0.051	0.058	0.061	0.0615	0.089	0.081	0.053	0.0605	0.046	0.0445	0.0475	0.044	0.092	0.092	0.0845	0.0845
Jul-01	0.05	0.058	0.0605	0.0615	0.094	0.081	0.0545	0.0605	0.0385	0.0445	0.0475	0.044	0.092	0.092	0.087	0.087
Aug-01	0.0515	0.058	0.06	0.0615	0.1	0.081	0.0555	0.0605	0.0425	0.0445	0.0425	0.044	0.092	0.092	0.0845	0.0845
Sep-01	0.052	0.058	0.059	0.0615	0.0875	0.081	0.0555	0.0605	0.045	0.0445	0.0425	0.044	0.0825	0.0825	0.077	0.077
Oct-01	0.0485	0.052	0.0595	0.0595	0.08	0.082	0.0555	0.054	0.045	0.0455	0.047	0.0425	0.0825	0.0825	0.078	0.078
Nov-01	0.049	0.052	0.0625	0.0625	0.081	0.082	0.0525	0.054	0.048	0.0455	0.047	0.0425	0.076	0.076	0.08	0.08
Dec-01	0.0525	0.052	0.0635	0.0635	0.082	0.082	0.0545	0.054	0.048	0.0455	0.047	0.0425	0.0745	0.0745	0.0775	0.0775
Jan-02	0.0505	0.052	0.0635	0.0635	0.085	0.082	0.056	0.054			0.047	0.0425	0.072	0.072	0.075	0.075
Feb-02	0.05	0.052	0.0625	0.0625	0.086	0.082	0.056	0.054				0.0425	0.0715	0.0715	0.076	0.076

Mar-02	0.05	0.052	0.0615	0.0615	0.083	0.082	0.0565	0.054	0.0505	0.0455		0.0425			0.0795	0.0795
Apr-02	0.05	0.052	0.062	0.062	0.084	0.082	0.0565	0.054				0.0425	0.0675	0.0675	0.0805	0.0805
May-02	0.0495	0.052	0.0605	0.0605	0.083	0.082	0.0545	0.054	0.042	0.0455		0.0425	0.0725	0.0725	0.081	0.081
Jun-02	0.051	0.052	0.0605	0.0605	0.0865	0.082	0.0515	0.054	0.0415	0.0455		0.0425	0.0695	0.0695	0.081	0.081
Jul-02	0.0555	0.052	0.0625	0.0625	0.09	0.082	0.053	0.054	0.0515	0.0455		0.0425	0.0685	0.0685	0.0835	0.0835
Aug-02	0.0595	0.052	0.0655	0.0655	0.089	0.082	0.053	0.054	0.0465	0.0455		0.0425	0.071	0.071	0.082	0.082
Sep-02	0.0625	0.052	0.0675	0.0675	0.085	0.082	0.065	0.054	0.045	0.0455		0.0425	0.076	0.076	0.0795	0.0795
Oct-02	0.0615	0.0615	0.0685	0.0685	0.085	0.0875	0.067	0.067	0.054	0.054		0.0425	0.076	0.076	0.0765	0.0765
Nov-02	0.06	0.06	0.0695	0.0695	0.084	0.0875	0.061	0.061	0.049	0.049	0.0415	0.0425	0.074	0.074	0.0745	0.0745
Dec-02	0.0575	0.0575	0.072	0.072	0.0835	0.0875	0.0605	0.0605	0.048	0.048	0.0425	0.0425	0.074	0.074	0.075	0.075
Jan-03	0.0565	0.0565	0.073	0.073	0.0885	0.0875	0.0625	0.0625	0.0485	0.0485	0.044	0.0425	0.072	0.072	0.0795	0.0795
Feb-03	0.058	0.058	0.069	0.069	0.094	0.0875	0.063	0.063	0.047	0.047	0.044	0.0425	0.0715	0.0715		
Mar-03	0.0575	0.0575	0.0705	0.0705	0.099	0.0875		0	0.0485	0.0485	0.0435	0.0425	0.072	0.072	0.0835	0.0835
Apr-03	0.0585	0.0585	0.0715	0.0715	0.1025	0.0875		0			0.0425	0.0425	0.0725	0.0725	0.0795	0.0795
May-03	0.0565	0.0565	0.076	0.076	0.115	0.0875	0.064	0.064	0.0505	0.0505	0.0435	0.0425	0.0785	0.0785	0.079	0.079
Jun-03	0.058	0.058	0.0675	0.0675	0.1155	0.0875	0.0625	0.0625	0.049	0.049	0.043	0.0425			0.08	0.08
Jul-03	0.0565	0.0565	0.07	0.07	0.1085	0.0875	0.0615	0.0615	0.0505	0.0505	0.042	0.0425			0.079	0.079
Aug-03	0.0535	0.0535	0.0675	0.0675	0.1075	0.0875	0.0595	0.0595	0.0455	0.0455	0.05	0.0425	0.082	0.082	0.0735	0.0735
Sep-03	0.059	0.059	0.0735	0.0735	0.0835	0.0875	0.058	0.058	0.0435	0.0435	0.0415	0.0425	0.0835	0.0835	0.081	0.081
Oct-03	0.0565	0.0565	0.07	0.07	0.105	0.105	0.0585	0.0585	0.046	0.046	0.042	0.0425	0.0835	0.0835	0.0805	0.0805
Nov-03	0.0595	0.0595	0.0725	0.0725	0.1	0.1	0.0575	0.0575	0.049	0.049	0.043	0.0425	0.1035	0.1035	0.102	0.102
Dec-03	0.0615	0.0615	0.072	0.072	0.0985	0.0985	0.058	0.058			0.046	0.0425	0.0965	0.0965	0.097	0.097
Jan-04	0.061	0.061	0.0745	0.0745	0.1005	0.1005	0.061	0.061	0.0565	0.0565	0.0465	0.0465	0.1035	0.1035	0.1095	0.1095
Feb-04	0.0655	0.0655	0.0745	0.0745	0.1045	0.1045	0.066	0.066	0.0605	0.0605	0.0465	0.0465	0.097	0.097	0.108	0.108
Mar-04	0.07	0.07	0.076	0.076	0.115	0.115	0.0685	0.0685	0.0555	0.0555	0.0475	0.0475	0.1085	0.1085	0.112	0.112
Apr-04	0.073	0.073	0.075	0.075	0.1175	0.1175					0.0485	0.0485	0.1095	0.1095	0.1145	0.1145
May-04	0.0735	0.0735	0.0775	0.0775	0.1225	0.1225	0.0785	0.0785	0.073	0.073	0.053	0.053	0.109	0.109	0.107	0.107
Jun-04	0.0755	0.0755	0.078	0.078	0.1225	0.1225	0.0795	0.0795	0.065	0.065	0.0515	0.0515	0.107	0.107	0.1025	0.1025
Jul-04	0.0635	0.0635	0.075	0.075	0.117	0.117	0.0795	0.0795	0.056	0.056	0.055	0.055	0.1045	0.1045	0.097	0.097
Aug-04	0.059	0.059	0.0725	0.0725	0.09	0.09	0.0645	0.0645	0.0525	0.0525	0.0475	0.0475	0.0815	0.0815	0.078	0.078

Table 4.23: Prices Used & Spot ($/lb)

	Supreme alfalfa	Supreme alfalfa	Rolled corn	Rolled corn	Rolled barley	Rolled barley	Cottonseed	Cottonseed	Hominy	Hominy	Mill run	Mill run	Almond hulls	Almond hulls
	Spot	Price used	Spot	Price used	Spot	Price used	Spot	Price used	Spot	Price used	Spot	Price used	Spot	Price used
Aug 99-1	0.06	0.06	0.05	0.05	0.05	0.05	0.09	0.09	0.05	0.05				
Aug 99-2	0.06	0.06	0.05	0.05	0.05	0.05	0.09	0.09	0.05	0.05			0.00	0.00
Aug 99-3	0.06	0.06	0.05	0.05	0.05	0.05	0.09	0.09	0.05	0.05			0.00	0.00
Aug 99-4	0.06	0.06	0.05	0.05	0.05	0.05	0.09	0.09	0.05	0.05			0.00	0.00
Aug 99-5	0.06	0.06	0.05	0.05	0.05	0.05	0.09	0.09	0.05	0.05			0.00	0.00
Sep 99-1	0.06	0.06	0.05	0.05	0.05	0.05	0.09	0.09	0.05	0.05			0.03	0.03
Sep 99-2	0.06	0.06	0.05	0.05	0.05	0.05	0.09	0.09	0.05	0.05			0.03	0.03
Sep 99-3	0.06	0.06	0.05	0.05	0.05	0.05	0.09	0.09	0.05	0.05			0.03	0.03
Sep 99-4	0.06	0.06	0.05	0.05	0.05	0.05	0.09	0.09	0.05	0.05			0.03	0.03
Oct 99-1	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06			0.03	0.03
Oct 99-2	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06			0.03	0.03
Oct 99-3	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06			0.03	0.03
Oct 99-4	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06			0.03	0.03
Oct 99-5	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06			0.03	0.03
Nov 99-1	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06			0.03	0.03
Nov 99-2	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06			0.03	0.03
Nov 99-3	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06			0.03	0.03
Nov 99-4	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06			0.03	0.03
Dec 99-1	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06				
Dec 99-2	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06			0.00	0.00
Dec 99-3	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06			0.00	0.00
Dec 99-4	0.06	0.06	0.05	0.06	0.06	0.06	0.08	0.08	0.05	0.06			0.00	0.00
Jan 00-1	0.07	0.07	0.05	0.06	0.06	0.06	0.08	0.08	0.06	0.06				
Jan 00-2	0.07	0.07	0.05	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.00	0.00
Jan 00-3	0.07	0.07	0.05	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.00	0.00
Jan 00-4	0.07	0.07	0.05	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.00	0.00
Jan 00-5	0.07	0.07	0.05	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.00	0.00
Feb 00-1	0.07	0.07	0.05	0.06	0.06	0.06	0.08	0.08	0.06	0.06				
Feb 00-2	0.07	0.07	0.05	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.00	0.00
Feb 00-3	0.07	0.07	0.05	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.00	0.00
Feb 00-4	0.07	0.07	0.05	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.00	0.00
Mar 00-1	0.06	0.06	0.06	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.04	0.04
Mar 00-2	0.06	0.06	0.06	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.04	0.04
Mar 00-3	0.06	0.06	0.06	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.04	0.04

Mar 00-4	0.06	0.06	0.06	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.04	0.04
Apr 00-1	0.06	0.06	0.06	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.05	0.04
Apr 00-2	0.06	0.06	0.06	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.05	0.04
Apr 00-3	0.06	0.06	0.06	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.05	0.04
Apr 00-4	0.06	0.06	0.06	0.06	0.06	0.06	0.08	0.08	0.06	0.06			0.05	0.04
May 00-1	0.06	0.06	0.06	0.06	0.06	0.06	0.09	0.08	0.06	0.06			0.05	0.04
May 00-2	0.06	0.06	0.06	0.06	0.06	0.06	0.09	0.08	0.06	0.06			0.05	0.04
May 00-3	0.06	0.06	0.06	0.06	0.06	0.06	0.09	0.08	0.06	0.06			0.05	0.04
May 00-4	0.06	0.06	0.06	0.06	0.06	0.06	0.09	0.08	0.06	0.06			0.05	0.04
May 00-5	0.06	0.06	0.06	0.06	0.06	0.06	0.09	0.08	0.06	0.06			0.05	0.04
Jun 00-1	0.06	0.06	0.06	0.06	0.06	0.06	0.09	0.08	0.05	0.06			0.04	0.04
Jun 00-2	0.06	0.06	0.06	0.06	0.06	0.06	0.09	0.08	0.05	0.06			0.04	0.04
Jun 00-3	0.06	0.06	0.06	0.06	0.06	0.06	0.09	0.08	0.05	0.06			0.04	0.04
Jun 00-4	0.06	0.06	0.06	0.06	0.06	0.06	0.09	0.08	0.05	0.06			0.04	0.04
Jly 00-1	0.06	0.06	0.05	0.06	0.06	0.06	0.09	0.08	0.05	0.06			0.05	0.04
Jly 00-2	0.06	0.06	0.05	0.06	0.06	0.06	0.09	0.08	0.05	0.06			0.05	0.04
Jly 00-3	0.06	0.06	0.05	0.06	0.06	0.06	0.09	0.08	0.05	0.06			0.05	0.04
Jly 00-4	0.06	0.06	0.05	0.06	0.06	0.06	0.09	0.08	0.05	0.06			0.05	0.04
Aug 00-1	0.06	0.06	0.05	0.06	0.05	0.06	0.09	0.08	0.05	0.06			0.04	0.04
Aug 00-2	0.06	0.06	0.05	0.06	0.05	0.06	0.09	0.08	0.05	0.06			0.04	0.04
Aug 00-3	0.06	0.06	0.05	0.06	0.05	0.06	0.09	0.08	0.05	0.06			0.04	0.04
Aug 00-4	0.06	0.06	0.05	0.06	0.05	0.06	0.09	0.08	0.05	0.06			0.04	0.04
Aug 00-5	0.06	0.06	0.05	0.06	0.05	0.06	0.09	0.08	0.05	0.06			0.04	0.04
Sep 00-1	0.06	0.06	0.05	0.06	0.05	0.06	0.08	0.08	0.05	0.06			0.04	0.04
Sep 00-2	0.06	0.06	0.05	0.06	0.05	0.06	0.08	0.08	0.05	0.06			0.04	0.04
Sep 00-3	0.06	0.06	0.05	0.06	0.05	0.06	0.08	0.08	0.05	0.06			0.04	0.04
Sep 00-4	0.06	0.06	0.05	0.06	0.05	0.06	0.08	0.08	0.05	0.06			0.04	0.04
Oct 00-1	0.06	0.06	0.05	0.06	0.05	0.06	0.09	0.08	0.05	0.06			0.05	0.04
Oct 00-2	0.06	0.06	0.05	0.06	0.05	0.06	0.09	0.08	0.05	0.06			0.05	0.04
Oct 00-3	0.06	0.06	0.05	0.06	0.05	0.06	0.09	0.08	0.05	0.06			0.05	0.04
Oct 00-4	0.06	0.06	0.05	0.06	0.05	0.06	0.09	0.08	0.05	0.06			0.05	0.04
Oct 00-5	0.06	0.06	0.05	0.06	0.05	0.06	0.09	0.08	0.05	0.06			0.05	0.04

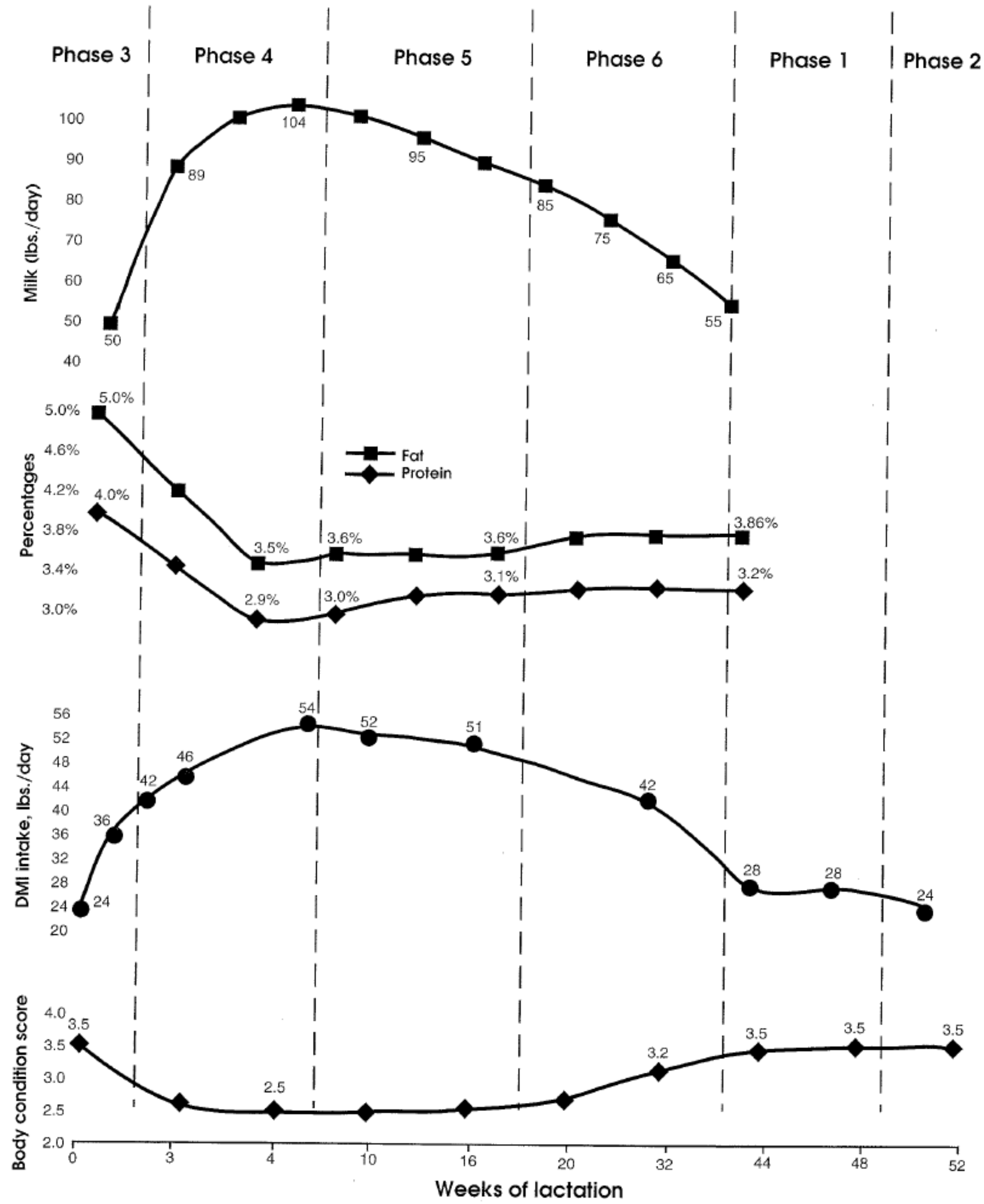
Table 4.24: Strips Months Model (SMM) Milk Prices ($/cwt)

	Class III-1	Class III-2	Class III-3	Class III-4	Class III-5	Class III-6	Class III-7	Class III-8	Class III-9	Class III-1(	Class III-1	Class III-12		3 month av	6 month av	12 month a	Rolling 5 y	BFP	Milk price	Difference
Jan-99	16.45	14.09	12.98	12.44	12.00	12.04	12.40	12.67	13.10	13.40	13.00			14.51	13.33	13.14	14.18	16.27	15.83	-0.44
Feb-99	11.84	11.85	12.07	11.83	11.92	12.25	12.60	12.90	13.12	12.95	12.51			11.92	11.96	12.35	14.32	10.27	11.33	1.06
Mar-99	11.28	11.00	10.82	11.03	11.90	12.63	13.10	13.34	13.07	12.72	12.25			11.03	11.44	12.10	14.31	11.62	12.34	0.72
Apr-99	11.29	10.88	10.83	11.42	12.25	12.76	12.89	12.79	12.63	12.20				11.00	11.57	11.99	14.30	11.81	11.81	0.00
May-99	11.42	11.12	11.41	12.24	12.64	12.85	12.77	12.60	12.19	12.00				11.32	11.95	12.12	14.28	11.26	11.26	0.00
Jun-99	11.95	12.97	13.17	13.49	13.43	13.00	12.75	12.15	12.14	12.00	11.80			12.70	13.00	12.62	14.28	11.42	11.42	0.00
Jul-99	13.5	13.7	13.68	13.35	13.25	12.9	12.36	12.21	12	11.85				13.63	13.40	12.88	14.28	13.59	13.59	0.00
Aug-99	16.2	16.75	16.65	15.5	14.6	13.25	12.6	12.18	11.8	11.8				16.53	15.49	14.13	14.32	15.79	15.69	-0.10
Sep-99	15.59	13.50	12.70	12.55	12.31	11.90	11.78	11.57	11.57	11.64	11.60			13.93	13.09	12.43	14.43	16.26	16.01	-0.25
Oct-99	12.8	12.52	12.35	12.25	11.93	11.85	11.65	11.6	11.76	12.45	12.6			12.56	12.28	12.16	14.55	11.49	12.81	1.32
Nov-99	11.00	11.35	11.67	11.60	11.65	11.70	11.61	11.80	12.40					11.34	11.50	11.64	14.55	9.79	11.67	1.88
Dec-99	9.98	10.77	10.81	11.07	11.34	11.41	11.70	12.54	12.85	13.05	13.10			10.52	10.90	11.69	14.55	9.63	11.56	1.93
Jan-00	10.26	10.50	10.57	10.91	11.08	11.70	12.55	12.82	12.95	12.95	12.75			10.44	10.84	11.73	14.56	10.05	11.85	1.80
Feb-00	10.06	10.27	10.52	10.96	11.56	12.43	12.73	12.85	12.82	12.31	12.03			10.28	10.97	11.69	14.57	9.54	9.54	0.00
Mar-00	9.95	10.15	10.60	11.30	12.16	12.62	12.66	12.70	12.20	12.05	11.39			10.23	11.13	11.62	14.57	9.54	9.54	0.00
Apr-00	9.62	9.90	10.86	11.70	12.22	12.51	12.60	12.00	11.73	11.20	11.00			10.13	11.14	11.39	14.58	9.41	9.41	0.00
May-00	9.65	10.50	11.55	12.10	12.30	12.35	11.88	11.55	10.85	10.65	10.71			10.57	11.41	11.28	14.58	9.37	9.37	0.00
Jun-00	9.85	11.55	12.01	12.47	12.45	11.97	11.80	11.25	11.15	11.09	10.85			11.14	11.72	11.49	14.59	9.46	9.46	0.00
Jul-00	11.11	12.30	12.71	12.65	12.15	11.96	11.10	11.05	11.05	10.84	10.85			12.04	12.15	11.62	14.59	10.66	10.66	0.00
Aug-00	10.25	10.34	10.90	10.85	10.85	10.70	10.70	10.70	10.60	10.60	10.90			10.50	10.65	10.67	14.59	10.13	10.13	0.00
Sep-00	10.69	11.05	10.80	10.60	10.55	10.52	10.55	10.60	10.55	11.06	11.35			10.85	10.70	10.76	14.59	10.76	10.76	0.00
Oct-00	10.35	9.95	9.95	10.05	10.05	10.05	9.85	9.85	10.50	10.90	10.93			10.08	10.07	10.22	14.58	10.02	10.02	0.00
Nov-00	8.90	9.25	9.75	9.79	9.80	9.84	9.91	10.33	10.78	11.00	11.10			9.30	9.56	10.04	14.56	8.57	8.57	0.00
Dec-00	9.34	9.75	9.82	9.90	10.19	10.20	10.60	11.11	11.33	11.44	11.45	11.25		9.64	9.87	10.53	14.55	9.37	9.37	0.00
Jan-01	9.80	9.82	9.95	10.02	10.07	10.55	11.06	11.32	11.40	11.40	11.05			9.86	10.04	10.59	14.53	9.99	9.99	0.00
Feb-01	10.02	10.27	10.47	10.60	11.10	11.95	12.05	12.01	12.05	11.57	11.42		Futures	10.25	10.74	11.23	14.50	10.27	10.27	0.00
Mar-01	11.40	11.08	11.10	11.63	12.14	12.27	12.27	12.27	11.70	11.50	11.10			11.19	11.60	11.68	14.48	11.42	11.42	0.00
Apr-01	12.00	12.60	13.34	13.40	13.40	13.28	12.58	11.96	12.00	11.19	11.10			12.65	13.00	12.44	14.46	12.08	12.08	0.00
May-01	13.93	14.17	14.16	14.10	14.14	13.42	12.73	12.26	11.66	11.58	11.65			14.09	13.99	13.07	14.44	13.83	13.83	0.00
Jun-01	14.90	15.47	15.46	15.45	14.40	13.81	12.92	12.05	11.85	11.60	11.65	11.65		15.28	14.92	13.43	14.44	15.02	14.99	-0.03
Jul-01	15.00	14.70	14.71	13.70	12.75	12.35	11.45	11.23	11.30	11.32	11.45	11.95		14.80	13.87	12.66	14.48	15.46	15.28	-0.18
Aug-01	15.35	15.38	14.80	13.80	13.32	12.13	11.99	11.99	11.99	11.84	11.76			15.18	14.13	13.12	14.52	15.55	15.34	-0.21
Sep-01	15.61	14.65	13.70	12.75	12.20	11.91	11.90	11.91	11.90	12.05	12.45	12.49		14.65	13.47	12.79	14.54	15.90	15.57	-0.33
Oct-01	14.95	13.65	12.85	12.16	11.80	11.85	11.92	11.93	12.11	12.45	12.60			13.82	12.88	12.57	14.56	14.60	14.70	0.10
Nov-01	11.00	11.34	11.50	11.80	11.75	11.93	11.90	12.13	12.77	12.77	12.78			11.28	11.55	11.97	14.58	11.31	12.50	1.19
Dec-01	11.72	11.65	11.65	11.80	11.90	11.90	12.13	12.98	12.96	13.03	12.65	12.40		11.67	11.77	12.23	14.57	11.80	11.80	0.00
Jan-02	11.43	11.38	11.47	11.65	11.70	12.39	13.10	13.16	13.30	12.85	12.60			11.43	11.67	12.28	14.58	11.87	11.87	0.00
Feb-02	11.95	11.46	11.75	11.75	12.30	13.19	13.35	13.42	12.81	12.40	12.11	11.84		11.72	12.07	12.36	14.58	11.63	11.63	0.00
Mar-02	10.55	11.21	11.53	12.10	13.00	13.10	13.28	12.75	12.45	12.23	11.60	11.60		11.10	11.92	12.12	14.57	10.65	10.65	0.00
Apr-02	10.80	11.22	12.05	12.86	13.30	13.50	12.80	12.60	12.35	11.70	11.60			11.36	12.29	12.25	14.54	10.85	10.85	0.00
May-02	11.02	11.52	12.43	12.95	13.20	12.75	12.25	12.00	11.70	11.55	11.55			11.66	12.31	12.08	14.54	10.82	10.82	0.00
Jun-02	10.45	11.00	11.85	12.30	11.84	11.84	11.75	11.50	11.40	11.36	11.48	11.64		11.10	11.55	11.53	14.54	10.09	10.09	0.00
Jul-02	9.57	10.66	11.90	11.95	11.75	11.65	11.50	11.50	11.50	11.45	11.59			10.71	11.25	11.37	14.54	9.33	9.33	0.00
Aug-02	9.62	11.25	10.85	11.71	11.78	11.79	11.79	11.79	11.70	11.65	11.65			10.57	11.17	11.42	14.54	9.54	9.54	0.00
Sep-02	9.90	10.00	10.46	10.51	11.00	11.15	11.30	11.40	11.50	11.65	12.10	12.35		10.12	10.50	11.11	14.52	9.92	9.92	0.00
Oct-02	10.49	10.50	10.50	10.58	10.77	11.25	11.40	11.68	12.05	12.57	12.70			10.50	10.68	11.32	14.49	10.72	10.72	0.00
Nov-02	9.70	9.67	10.20	10.37	10.70	11.02	11.38	11.85	12.44	12.65	12.85	12.48		9.86	10.28	11.28	14.46	9.84	9.84	0.00
Dec-02	10.02	10.52	10.77	11.25	11.44	11.70	12.17	12.72	12.88	13.25	12.77	12.50		10.44	10.95	11.83	14.42	9.74	9.74	0.00
Jan-03	9.84	10.22	10.85	11.19	11.58	12.18	12.67	13.02	13.38	12.67	12.36			10.30	10.98	11.81	14.37	9.78	9.78	0.00
Feb-03	9.70	9.75	9.90	10.12	10.51	11.20	11.91	12.33	12.01	11.94	11.80	11.71		9.78	10.20	11.07	14.33	9.66	9.66	0.00
Mar-03	9.15	9.52	9.85	10.30	10.80	11.10	11.65	11.52	11.43	11.40	11.50	11.30		9.51	10.12	10.79	14.28	9.11	9.11	0.00
Apr-03	9.36	9.93	10.35	10.82	11.07	11.72	11.80	11.60	11.65	11.65	11.70			9.88	10.54	11.06	14.24	9.41	9.41	0.00
May-03	9.90	10.50	11.30	11.73	12.43	12.26	11.93	11.70	11.60	11.54	11.44			10.57	11.35	11.48	14.21	9.71	9.71	0.00
Jun-03	9.81	10.50	11.33	12.07	12.10	12.12	11.90	11.75	11.70	11.60	11.40	11.35		10.55	11.32	11.47	14.21	9.75	9.75	0.00
Jul-03	11.70	12.65	13.19	13.08	12.45	12.14	11.95	11.75	11.80	11.60	11.60			12.51	12.54	12.17	14.16	11.78	11.78	0.00
Aug-03	13.89	14.53	13.70	12.94	12.49	12.08	11.76	11.80	11.75	11.55	11.85	12.25		14.04	13.27	12.55	14.07	13.80	13.80	0.00
Sep-03	14.13	13.82	12.50	11.89	11.80	11.20	11.30	11.25	11.25	11.75	12.01			13.48	12.56	12.08	14.03	14.30	14.30	0.00
Oct-03	14.12	12.65	11.75	11.57	11.23	11.24	11.20	11.10	11.90	12.29	12.65	13.15		12.84	12.09	12.07	14.00	14.39	14.39	0.00
Nov-03	13.16	11.75	11.51	11.26	11.30	11.25	11.23	11.95	12.35	12.70	13.30	12.60		12.14	11.71	12.03	13.93	13.47	13.47	0.00
Dec-03	11.43	11.50	11.30	11.35	11.45	11.44	12.00	12.47	12.93	13.38	12.75	12.10		11.41	11.41	12.01	13.78	11.87	11.87	0.00
Jan-04	11.54	11.45	11.45	11.64	11.60	12.24	12.71	13.05	13.56	12.99	12.10	11.60		11.48	11.65	12.16	13.56	11.61	11.61	0.00
Feb-04	11.63	12.05	12.43	12.65	12.98	13.68	14.18	14.58	13.88	12.95	12.40	12.06		12.04	12.57	12.96	13.39	11.89	11.89	0.00
Mar-04	13.48	14.13	14.42	14.60	14.70	14.87	15.18	14.10	12.90	12.40	11.83	11.80		14.01	14.37	13.70	13.41	14.49	14.10	-0.39
Apr-04	18.91	18.88	17.81	17.02	16.96	16.80	15.35	13.94	13.23	12.40	12.35	12.35		18.53	17.73	15.50	13.50	19.66	16.68	-2.98
May-04	19.96	17.03	15.62	15.63	15.28	14.50	13.09	12.15	11.95	11.90	11.85	12.05		17.54	16.34	14.25	13.88	20.58	17.14	-3.44
Jun-04	16.90	14.64	14.59	14.33	13.80	13.00	12.10	12.20	12.10	12.00	12.15	12.35		15.38	14.54	13.35	14.31	17.68	15.69	-1.99
Jul-04	14.89	13.64	13.86	13.40	12.60	12.16	12.30	12.25	12.25	12.35	12.35	12.65		14.13	13.43	12.89	14.53	14.85	14.28	-0.57
Aug-04	14.27	16.02	15.15	13.45	12.61	12.40	12.30	12.25	12.25	12.21	12.25	12.75		15.15	13.98	13.16	14.57	14.04	13.87	-0.17
Sep-04	14.45	13.49	12.60	12.20	11.90	11.90	11.90	12.08	12.10	12.30	12.73	12.95		13.51	12.76	12.55	14.51	14.72	14.21	-0.51
Oct-04	13.95	12.94	12.30	12.00	12.00	12.05	12.00	12.00	12.35	12.75	13.13	13.35		13.06	12.54	12.57	14.44	14.16	13.93	-0.23
Nov-04	14.15	12.97	12.41	12.25	12.26	11.98	11.98	12.26	12.67	13.25	13.45	12.75		13.18	12.67	12.70	14.51	14.89	14.30	-0.59

Table 4.25: Individual Months Model (IMM) Milk Prices ($/cwt)

	Class III-1	Class III-2	Class III-3	Class III-4	Class III-5	Class III-6	Class III-7	Class III-8	Class III-9	Class III-1(	Class III-1	Class III-12	Rolling 5 yr ave + 1 sd	Actual BFP	Milk price	Actual BFF
Jan-99	16.45	14.09	12.98	12.44	12.00	12.04	12.40	12.67	13.10	13.40	13.00		14.18	16.27	16.45	16.27
Feb-99	11.84	11.85	12.07	11.83	11.92	12.25	12.60	12.90	13.12	12.95	12.51		14.32	10.27	10.27	10.27
Mar-99	11.28	11.00	10.82	11.03	11.90	12.63	13.10	13.34	13.07	12.72	12.25		14.31	11.62	11.62	11.62
Apr-99	11.29	10.88	10.83	11.42	12.25	12.76	12.89	12.79	12.63	12.20			14.30	11.81	11.81	11.81
May-99	11.42	11.12	11.41	12.24	12.64	12.85	12.77	12.60	12.19	12.00			14.28	11.26	11.26	11.26
Jun-99	11.95	12.97	13.17	13.49	13.43	13.00	12.75	12.15	12.14	12.00	11.80		14.28	11.42	11.42	11.42
Jul-99	13.50	13.70	13.68	13.35	13.25	12.90	12.36	12.21	12.00	11.85			14.28	13.59	13.59	13.59
Aug-99	16.20	16.75	16.65	15.50	14.60	13.25	12.60	12.18	11.80	11.80			14.32	15.79	16.20	15.79
Sep-99	15.59	13.50	12.70	12.55	12.31	11.90	11.78	11.57	11.57	11.64	11.60		14.43	16.26	16.75	16.26
Oct-99	12.80	12.52	12.35	12.25	11.93	11.85	11.65	11.60	11.76	12.45	12.60		14.55	11.49	16.65	11.49
Nov-99	11.00	11.35	11.67	11.60	11.65	11.70	11.61	11.80	12.40				14.55	9.79	15.50	9.79
Dec-99	9.98	10.77	10.81	11.07	11.34	11.41	11.70	12.54	12.85	13.05	13.10		14.55	9.63	14.60	9.63
Jan-00	10.26	10.50	10.57	10.91	11.08	11.70	12.55	12.82	12.95	12.95	12.75		14.56	10.05	10.05	10.05
Feb-00	10.06	10.27	10.52	10.96	11.56	12.43	12.73	12.85	12.82	12.31	12.03		14.57	9.54	9.54	9.54
Mar-00	9.95	10.15	10.60	11.30	12.16	12.62	12.66	12.70	12.20	12.05	11.39		14.57	9.54	9.54	9.54
Apr-00	9.62	9.90	10.86	11.70	12.22	12.51	12.60	12.00	11.73	11.20	11.00		14.58	9.41	9.41	9.41
May-00	9.65	10.50	11.55	12.10	12.30	12.35	11.88	11.55	10.85	10.65	10.71		14.58	9.37	9.37	9.37
Jun-00	9.85	11.55	12.01	12.47	12.45	11.97	11.80	11.25	11.15	11.09	10.85		14.59	9.46	9.46	9.46
Jul-00	11.11	12.30	12.71	12.65	12.15	11.96	11.10	11.05	11.05	10.84	10.85		14.59	10.66	10.66	10.66
Aug-00	10.25	10.34	10.90	10.85	10.85	10.70	10.70	10.70	10.60	10.60	10.90		14.59	10.13	10.13	10.13
Sep-00	10.69	11.05	10.80	10.60	10.55	10.52	10.55	10.60	10.55	11.06	11.35		14.59	10.76	10.76	10.76
Oct-00	10.35	9.95	9.95	10.05	10.05	10.05	9.85	9.85	10.50	10.90	10.93		14.58	10.02	10.02	10.02
Nov-00	8.90	9.25	9.75	9.79	9.80	9.84	9.91	10.33	10.78	11.00	11.10		14.56	8.57	8.57	8.57
Dec-00	9.34	9.75	9.82	9.90	10.19	10.20	10.60	11.11	11.33	11.44	11.45	11.25	14.55	9.37	9.37	9.37
Jan-01	9.80	9.82	9.95	10.02	10.07	10.55	11.06	11.32	11.40	11.40	11.05		14.53	9.99	9.99	9.99
Feb-01	10.02	10.27	10.47	10.60	11.10	11.95	12.05	12.01	12.05	11.57	11.42		14.50	10.27	10.27	10.27
Mar-01	11.40	11.08	11.10	11.63	12.14	12.27	12.27	12.27	11.70	11.50	11.10		14.48	11.42	11.42	11.42
Apr-01	12.00	12.60	13.34	13.40	13.40	13.28	12.58	11.96	12.00	11.19	11.10		14.46	12.08	12.08	12.08
May-01	13.93	14.17	14.16	14.10	14.14	13.42	12.73	12.26	11.66	11.58	11.65		14.44	13.83	13.83	13.83
Jun-01	14.90	15.47	15.46	15.45	14.40	13.81	12.92	12.05	11.85	11.60	11.65	11.65	14.44	15.02	14.90	15.02
Jul-01	15.00	14.70	14.71	13.70	12.75	12.35	11.45	11.23	11.30	11.32	11.45	11.95	14.48	15.46	15.47	15.46
Aug-01	15.35	15.38	14.80	13.80	13.32	12.13	11.99	11.99	11.99	11.84	11.76		14.52	15.55	15.46	15.55
Sep-01	15.61	14.65	13.70	12.75	12.20	11.91	11.90	11.91	11.90	12.05	12.45	12.49	14.54	15.90	15.45	15.90
Oct-01	14.95	13.65	12.85	12.16	11.80	11.85	11.92	11.93	12.11	12.45	12.60		14.56	14.60	0.00	14.60
Nov-01	11.00	11.34	11.50	11.80	11.75	11.93	11.90	12.13	12.77	12.77	12.78		14.58	11.31	11.31	11.31
Dec-01	11.72	11.65	11.65	11.80	11.90	11.90	12.13	12.98	12.96	13.03	12.65	12.40	14.57	11.80	11.80	11.80
Jan-02	11.43	11.38	11.47	11.65	11.70	12.39	13.10	13.16	13.30	12.85	12.60		14.58	11.87	11.87	11.87
Feb-02	11.95	11.46	11.75	11.75	12.30	13.19	13.35	13.42	12.81	12.40	12.11	11.84	14.58	11.63	11.63	11.63
Mar-02	10.55	11.21	11.53	12.10	13.00	13.10	13.28	12.75	12.45	12.23	11.60	11.60	14.57	10.65	10.65	10.65
Apr-02	10.80	11.22	12.05	12.86	13.30	13.50	12.80	12.60	12.35	11.70	11.60		14.54	10.85	10.85	10.85
May-02	11.02	11.52	12.43	12.95	13.20	12.75	12.25	12.00	11.70	11.55	11.55		14.54	10.82	10.82	10.82
Jun-02	10.45	11.00	11.85	12.30	11.84	11.84	11.75	11.50	11.40	11.36	11.48	11.64	14.54	10.09	10.09	10.09
Jul-02	9.57	10.66	11.90	11.95	11.75	11.65	11.50	11.50	11.50	11.45	11.59		14.54	9.33	9.33	9.33
Aug-02	9.62	11.25	10.85	11.71	11.78	11.79	11.79	11.79	11.70	11.65	11.65		14.54	9.54	9.54	9.54
Sep-02	9.90	10.00	10.46	10.51	11.00	11.15	11.30	11.40	11.50	11.65	12.10	12.35	14.52	9.92	9.92	9.92
Oct-02	10.49	10.50	10.50	10.58	10.77	11.25	11.40	11.68	12.05	12.57	12.70		14.49	10.72	10.72	10.72
Nov-02	9.70	9.67	10.20	10.37	10.70	11.02	11.38	11.85	12.44	12.65	12.85	12.48	14.46	9.84	9.84	9.84
Dec-02	10.02	10.52	10.77	11.25	11.44	11.70	12.17	12.72	12.88	13.25	12.77	12.50	14.42	9.74	9.74	9.74
Jan-03	9.84	10.22	10.85	11.19	11.58	12.18	12.67	13.02	13.38	12.67	12.36		14.37	9.78	9.78	9.78
Feb-03	9.70	9.75	9.90	10.12	10.51	11.20	11.91	12.33	12.01	11.94	11.80	11.71	14.33	9.66	9.66	9.66
Mar-03	9.15	9.52	9.85	10.30	10.80	11.10	11.65	11.52	11.43	11.40	11.50	11.30	14.28	9.11	9.11	9.11
Apr-03	9.36	9.93	10.35	10.82	11.07	11.72	11.80	11.60	11.65	11.65	11.70		14.24	9.41	9.41	9.41
May-03	9.90	10.50	11.30	11.73	12.43	12.26	11.93	11.70	11.60	11.54	11.44		14.21	9.71	9.71	9.71
Jun-03	9.81	10.50	11.33	12.07	12.10	12.12	11.90	11.75	11.70	11.60	11.40	11.35	14.21	9.75	9.75	9.75
Jul-03	11.70	12.65	13.19	13.08	12.45	12.14	11.95	11.75	11.80	11.60	11.60		14.16	11.78	11.78	11.78
Aug-03	13.89	14.53	13.70	12.94	12.49	12.08	11.76	11.80	11.75	11.55	11.85	12.25	14.07	13.80	13.80	13.80
Sep-03	14.13	13.82	12.50	11.89	11.80	11.20	11.30	11.25	11.25	11.75	12.01		14.03	14.30	0.00	14.30
Oct-03	14.12	12.65	11.75	11.57	11.23	11.24	11.20	11.10	11.90	12.29	12.65	13.15	14.00	14.39	0.00	14.39
Nov-03	13.16	11.75	11.51	11.26	11.30	11.25	11.23	11.95	12.35	12.70	13.30	12.60	13.93	13.47	13.47	13.47
Dec-03	11.43	11.50	11.30	11.35	11.45	11.44	12.00	12.47	12.93	13.38	12.75	12.10	13.78	11.87	11.87	11.87
Jan-04	11.54	11.45	11.45	11.64	11.60	12.24	12.71	13.05	13.56	12.99	12.10	11.60	13.56	11.61	11.61	11.61
Feb-04	11.63	12.05	12.43	12.65	12.98	13.68	14.18	14.58	13.88	12.95	12.40	12.06	13.39	11.89	11.89	11.89
Mar-04	13.48	14.13	14.42	14.60	14.70	14.87	15.18	14.10	12.90	12.40	11.83	11.80	13.41	14.49	13.48	13.48
Apr-04	18.91	18.88	17.81	17.02	16.96	16.80	15.35	13.94	13.23	12.40	12.35	12.35	13.50	19.66	14.13	19.66
May-04	19.96	17.03	15.62	15.63	15.28	14.50	13.09	12.15	11.95	11.90	11.85	12.05	13.88	20.58	14.42	20.58
Jun-04	16.90	14.64	14.59	14.33	13.80	13.00	12.10	12.20	12.10	12.00	12.15	12.35	14.31	17.68	14.60	17.68
Jul-04	14.89	13.64	13.86	13.40	12.60	12.16	12.30	12.25	12.25	12.35	12.35	12.65	14.53	14.85	13.68	14.85
Aug-04	14.27	16.02	15.15	13.45	12.61	12.40	12.30	12.25	12.25	12.21	12.25	12.75	14.57	14.04	12.98	14.04
Sep-04	14.45	13.49	12.60	12.20	11.90	11.90	11.90	12.08	12.10	12.30	12.73	12.95	14.51	14.72	14.58	14.72
Oct-04	13.95	12.94	12.30	12.00	12.00	12.05	12.00	12.00	12.35	12.75	13.13	13.35	14.44	14.16	13.88	14.16
Nov-04	14.15	12.97	12.41	12.25	12.26	11.98	11.98	12.26	12.67	13.25	13.45	12.75	14.51	14.89	13.94	14.89
Dec-04	16.88	14.88	13.85	13.05	12.95	12.70	12.65	12.85	13.28	13.54	12.89	12.21	14.61	16.14	16.88	

Figure 4.1: Lactation and Gestation Cycle Phases with Changes in Milk Production, Milk Fat Percent, Milk Protein Percent, DMI Intake and Body Condition Scores for Holsteins (21,000 lbs. Milk)



Source: Hutjens (2003)

Figure 4.2: Typical Milk Production, Cow BW, and DMI for Standard Cycle

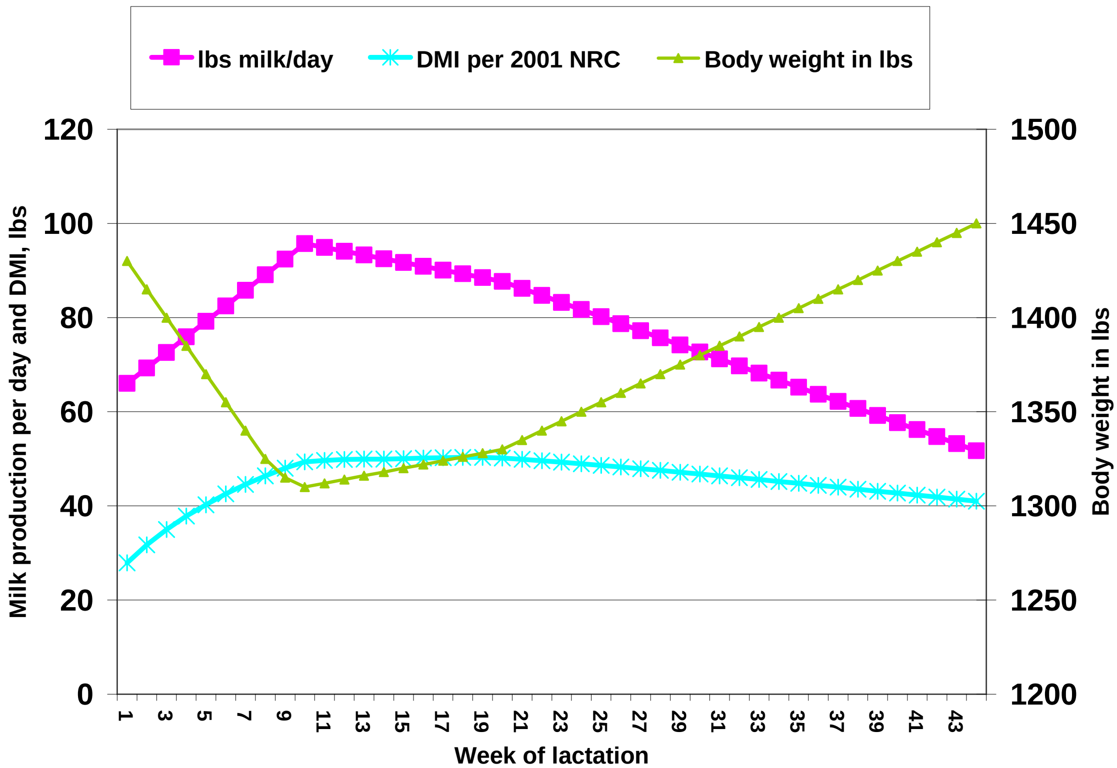


Figure 4.3: Net Energy vs. Milk Production Functions

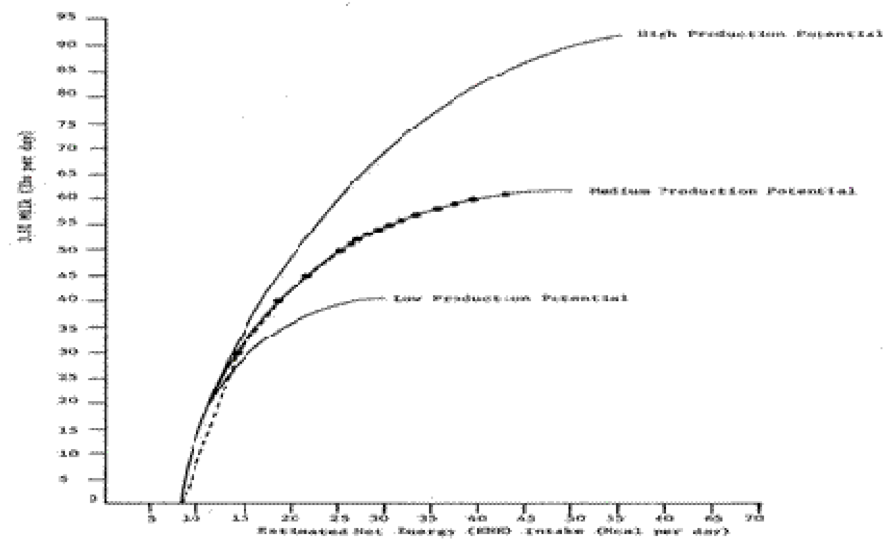
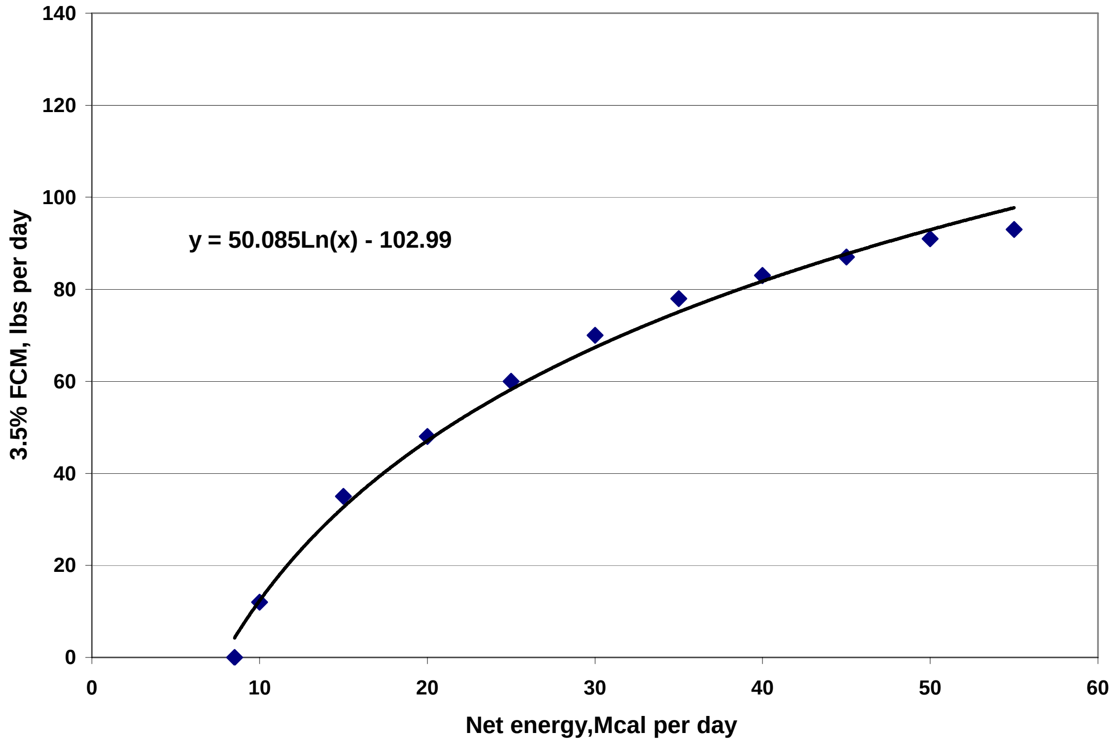


Fig. 14. Estimated milk response of a 1,400-pound cow of varying energy intake.

Source: Dean at al. 1972

Figure 4.4: Derived Milk Production



CHAPTER V: RESULTS

This chapter reports the results of the optimization models using either spot or forward feed and milk prices with least-cost or profit-max formulations. Section 5.1 describes the feed price results using spot or forward feed prices. Section 5.2 reports on the milk price results using either spot values, the SMM forward prices, or the IMM forward prices. Section 5.3 details the ration model results identifying those strategies that achieve the highest average daily net return ($/day). Finally these returns are measured against the amount of risk, as defined by the average profit per day standard deviation, associated with achieving these returns. Section 5.4 details the tests of statistical significance to see if the means and variances of the spot versus forward feed and milk prices and ration formulations results were statistically different each other.

5.1 Feed Price Results

Of the 16 ingredients listed in the feed library, five of those ingredients, alfalfa hay, beet pulp, fat, molasses, and rice bran there was little or no forward contract information so spot values were used for both the least-cost and profit-maximization models. Of the other 11 ingredients, two of them, canola meal and distillers grain, had no forward contracting opportunities that met the criteria..This is due to the fact that for canola meal, forward values were not incorporated until September 2002 while DDG did not have forward values until November 2003. Of the nine remaining ingredients, four had lower overall average prices via forward contracting while the other five had lower prices with spot values. Table 5.1 reports the summary statistics for all ingredient prices including the average price in $/lb. along with their respective standard deviation, coefficient of variation, the minimum, and maximum values. There were four ingredients that had lower prices with forward contracting as opposed to spot. Almond hulls were lower cost by an average of $0.1426 per pound followed by soybean meal at $0.0068 per pound, then cottonseed at $0.0040 per pound, and finally cottonseed meal at $0.0001 per pound. Of the five ingredients where the average spot price was lower than the average forward contract price, soyhull pellets were $0.0189 per pound less expensive followed by corn at $0.0019 per pound, hominy at $0.0016 per pound, barley at $0.004 per pound, and wheat millrun at $0.0001 per pound.

One of the reasons producers forward contract feed ingredients in addition to taking advantage of what they see as an attractive price is to reduce the volatility in prices paid. The coefficient of variation which is a measure of price volatility shows that of the nine feed ingredients that had forward contracting opportunities, the coefficient of variation for spot values was higher for six ingredients and lower for the other three. Corn, hominy, barley, cottonseed, almond hulls, and wheat millrun had lower CV's for forward as opposed to spot values. Soybean meal, soyhull pellets, almond hulls, and cottonseed meal had lower CV's for forward as opposed to spot values.

With regard to the number of times that an ingredient was forward contracted, cottonseed had the highest percent (72%) with 190 weeks of the 264 week period where the price was the forward contracted. This was followed by almond hulls at a slightly less than 72.0%, hominy at 59.0%, rolled corn at 58.7%, rolled barley at 37.1%, mill run at 34.6%, cottonseed meal at 5.9%, and soyhulls at 3.9%.

5.2 Milk Price Results

The ration model used three different milk price series, the BFP/Class III cash price, the Strips Month Model (SMM) that used three, six, and twelve months strips of

Class III futures, and Individual Months Model (IMM) that used individual months of Class III futures. Table 5.2 summarizes the statistics for all three price series.

The spot or BFP price was the highest over the 264 weeks. The IMM and SMM had the second and third highest prices, respectively. The corresponding standard deviations had the same pattern. The spot had the highest standard deviation followed by the IMM and SMM. The coefficient of variation (CV) statistics followed the same pattern. The highest milk price was achieved by using spot values, but this strategy also entailed higher risk as measured by SD and CV. The data also shows that for the 264-week period extending from August 1999 to August 2004, the SMM milk prices were used in 78 weeks or 29.5% of the time while the IMM milk prices were used in 71 weeks or 26.9% of the study period.

5.3 Ration Model Results

Using two sets of feed prices, spot or forward, three sets of milk prices, spot, SMM, or IMM, and either the least-cost or profit-max formulations, the optimization model generated 12 sets of results including the average daily net returns. Figure 5.1 shows that in all cases the average daily net returns for the profit-maximization method exceed those of the least-cost method. The highest net return using the least cost method was $6.40/day using IMM milk prices and forward feed values. Each scenario has the method of optimization listed first; either least-cost (LC) or profit-max (PM). The milk price series is listed second, the cash or Basic Formula Price (BFP), Strips Months Model (SMM), or the Individual Months Model (IMM). The third item is whether (SPOT) or (FORWARD) feed prices are used.

Average values for milk production (lbs/day), NEL (Mcal/day), CP (lbs/day), DMI (lbs/day), milk revenues ($/day), feed costs ($/day), and net returns ($/day) are listed in

Table 5.3. The highest milk production of 84.73 lbs/day was observed for PM-SMM-FORWARD. The second highest milk production at 84.69 lbs/day was observed with PM-BFP-SPOT. These two strategies also had the highest net energy for lactation (NEL). Higher net energy intake leads to higher milk production. The LC-IMM-SPOT strategy resulted in the lowest milk production at 82.29 lbs/day. The second lowest milk production at 82.37 pounds per day occurred in the LC-SMM-SPOT strategy. Not surprisingly, these two scenarios also had the lowest NEL intake levels. The highest dry matter intake (DMI) of 51.24 pounds per day occurred with the PM-BFP-SPOT strategy. The second highest DMI of 50.94 pounds per day occurred in the PM-SMM-FORWARD strategy. This is the same combination that yielded the highest milk production. The lowest DMI figures of 49.28 and 49.32 were associated with the two lowest milk production strategies; the LC-IMM-SPOT and the LC-SMM-SPOT strategies.

The PM-IMM-SPOT strategy yielded the highest milk revenues of $10.11 per day and the PM-BFP-FORWARD resulted in the second highest milk revenues of $10.10 per day. The LC-SMM-SPOT strategy had the lowest milk revenues per day of $9.75 per day and the LC-IMM-SPOT strategy resulted in the second lowest revenues of $9.76 per day. The LC-SMM-SPOT strategy resulted in the lowest feed costs of $3.38 per day. This scenario also generated the least amount of milk. The LC-IMM-SPOT strategy had the second lowest feed costs of $3.39 per day. This strategy also had the second lowest amount of milk. The PM-BFP-SPOT strategy resulted in the highest feed costs of $3.54 per day. This strategy also had the highest daily dry matter intake and the second highest milk production per day. The PM-SMM-FORWARD strategy had the second highest feed costs of $3.52 per day. This strategy also had the highest milk production per day.

The final and perhaps most telling statistic was the daily net returns calculated as milk revenues per day minus the feed costs per day. The PM-BFP-SPOT strategy had the highest net of \$6.58 per day. This was not the strategy that had the highest milk production, the highest milk revenues, or the lowest feed costs. The PM-SMM-FORWARD had the second highest net returns of \$6.57 per day. This strategy did have the highest milk production. The LC-SMM-SPOT strategy yielded the lowest daily returns of \$6.36, the same strategy that resulted in the lowest milk revenues. The LC-IMM-SPOT had the second lowest net return of \$6.37 along with the second lowest milk revenues. The increased net returns generated by the profit-maximization model vs. that of the least-cost model range from \$0.19 per day for BFP-FORWARD to \$0.14 for the SMM-SPOT strategy.

Table 5.4 presents the complete model statistical summary. For milk production (lbs/day), NEL (Mcal/day), CP (lbs/day), DMI (lbs/day), milk revenues (\$/day), feed costs (\$/day), net returns (\$/day), and lbs/day fed for all the feed ingredients the average, standard deviation, coefficient of variation, minimum, maximum, and the range of values are presented. While all the variables are important, the main area of interest is net returns per day.

Table 5.5 reports the average, standard deviation, coefficient of variation, minimum, maximum, and the range of values of the net returns for all 12 scenarios. Earlier in this paper, the inverse relation between risk and reward is discussed. The results in Table 5.5 bear this out. The PM-BFP-FORWARD strategy has the highest average at \$6.58 but also has the highest standard deviation of \$2.41 and coefficient of variation at

36.61. The LC-SMM-FORWARD had the lowest risk as measured by the standard deviation and coefficient of variation values but only ranked tenth in net returns.

Another method of comparing the results is to graph the average net returns vs. the standard deviation (SD) of net returns (Figure 5.2). This risk-reward analysis looks at the net returns of each of the 12 strategies and compares them to their respective risk measured by standard deviation. In general, higher rewards, in this case higher net returns, have higher levels of risk as measured by standard deviation. The best strategy is one that offers the highest return with the lowest level of risk. There is no one single strategy that does this.

5.4 Tests for Statistical Significance

T tests were used to determine if the means for the cash versus forward contract feed and milk prices were statistically significant from each other. Further, F tests were used to determine if the variances for the cash versus forward contract feed and milk prices were statistically significant from each other. The means between the spot and forward prices are statistically different at the 5% level for soybean meal, soybean hull pellets, cottonseed, corn and almond hulls. The variances are statistically different for soybean hull pellets, corn, and almond hulls. For milk prices, the means for both the BFP and SMM and the BFP and IMM are not statistically different from each other, the variances for both BFP and SMM and BFP and IMM are statistically different from each other.

For the ration results, T-tests indicate that none of the net return means are statistically different from each other. The F- tests indicate that the variances are statistically different from each other for many of the strategies so risk does matter. If a person does not care about risk (risk neutral) they would choose PM-BFP-Forward (highest mean net return). More risk averse producers would likely choose PM-SMM-Forward.

Table 5.1: Feed Ingredient Cost Summary

Spot Values	Alfalfa Early bloom	Almond Hulls	Barley grain	Beet Pulp	Canola Meal	Corn grain, flaked	Cottonseed, whole fuzzy	Cottonseed Meal 41%	Dried Distillers Grain, corn	Fat	Hominy	Molasses	Rice Bran	Soybean Hulls, pelleted	Soybean Meal 48%	Wheat Middlings
Ave	0.0701	0.2510	0.0645	0.5246	0.0948	0.0557	0.0916	0.2941	0.1543	0.1400	0.1002	0.0500	0.8131	0.0508	0.1082	0.4236
SD	0.0073	0.3938	0.0070	0.4692	0.1131	0.0063	0.0121	0.3879	0.2741	0.0000	0.1969	0.0000	0.3781	0.0099	0.0215	0.4656
CV	10.47	156.90	10.80	89.44	119.29	11.36	13.16	131.90	177.63	0.00	196.48	0.00	46.51	19.40	19.84	109.90
Min	0.0572	0.0285	0.0535	0.0575	0.0615	0.0455	0.0785	0.0625	0.0565	0.1400	0.0460	0.0500	0.0435	0.0000	0.0850	0.0380
Max	0.0861	1.0000	0.0780	1.0000	1.0000	0.0755	0.1225	1.0000	1.0000	0.1400	1.0000	0.0500	1.0000	0.0700	0.1745	1.0000
Range	0.0288	0.9715	0.0245	0.9425	0.9385	0.0300	0.0440	0.9375	0.9435	0.0000	0.9540	0.0000	0.9565	0.0700	0.0895	0.9620
Forward values	Alfalfa Early bloom	Almond Hulls	Barley grain	Beet Pulp	Canola Meal	Corn grain, flaked	Cottonseed, whole fuzzy	Cottonseed Meal 41%	Dried Distillers Grain, corn	Fat	Hominy	Molasses	Rice Bran	Soybean Hulls, pelleted	Soybean Meal 48%	Wheat Middlings
Ave	0.0701	0.1084	0.0649	0.5246	0.0948	0.0577	0.0876	0.2940	0.1543	0.1400	0.1018	0.0500	0.8131	0.0697	0.1015	0.4238
SD	0.0073	0.2417	0.0064	0.4692	0.1131	0.0051	0.0110	0.3879	0.2741	0.0000	0.1965	0.0000	0.3781	0.1297	0.0231	0.4655
CV	10.47	222.93	9.92	89.44	119.29	8.78	12.51	131.94	177.63	0.00	192.94	0.00	46.51	185.95	22.77	109.83
Min	0.0572	0.0285	0.0535	0.0575	0.0615	0.0520	0.0810	0.0625	0.0565	0.1400	0.0490	0.0500	0.0435	0.0410	0.0850	0.0435
Max	0.0861	1.0000	0.0780	1.0000	1.0000	0.0755	0.1225	1.0000	1.0000	0.1400	1.0000	0.0500	1.0000	1.0000	0.1745	1.0000
Range	0.0288	0.9715	0.0245	0.9425	0.9385	0.0235	0.0415	0.9375	0.9435	0.0000	0.9510	0.0000	0.9565	0.9590	0.0895	0.9565
Ave spot - ave forward	0.0000	0.1426	-0.0004	0.0000	0.0000	-0.0019	0.0040	0.0001	0.0000	0.0000	-0.0016	0.0000	0.0000	-0.0189	0.0068	-0.0001
Spot CV - forward CV	0.00	-66.03	0.88	0.00	0.00	2.58	0.65	-0.04	0.00	0.00	3.54	0.00	0.00	-166.54	-2.93	0.07

Table 5.2: Milk Price Summary Statistics

	BFP	SMM	IMM
AVE	11.88	11.85	11.86
SD	2.71	2.29	2.31
CV	22.84	19.32	19.46
Min	8.57	8.57	8.57
Max	20.58	17.14	16.75
Range	12.01	8.57	8.18

BFP is the Basic Formula or cash milk price

SMM is the Strips Months Model that uses 3, 6, and 12 month strips of Class III futures

IMM is the Individual Months Model that uses individual months of Class III futures

Table 5.3: Summary of Milk Production, Net Energy for Lactation, Crude Protein, Dry Matter Intake, Milk Revenue, Feed Costs, and Net Return Statistics by Strategy

Model	Milk Price	Feed Price	Milk prod lbs/day	NEL Mcal/day	CP lbs./day	DMI lbs/day	Milk revenues $/day	Feed costs $/day	Profit $/day
LC	BFP	Spot	82.75	40.93	7.40	49.54	9.81	3.42	6.39
PM	BFP	Spot	84.69	42.68	7.40	51.24	10.11	3.54	6.57
LC	BFP	Forward	82.70	40.89	7.40	49.54	9.81	3.41	6.40
PM	BFP	Forward	84.57	42.55	7.40	50.77	10.10	3.51	6.58
LC	SMM	Spot	82.37	40.62	7.40	49.32	9.75	3.39	6.36
PM	SMM	Spot	83.89	41.94	7.40	50.42	9.98	3.48	6.50
LC	SMM	Forward	82.75	40.94	7.40	49.59	9.80	3.41	6.39
PM	SMM	Forward	84.73	42.71	7.40	50.94	10.09	3.52	6.57
LC	IMM	Spot	82.29	40.55	7.40	49.28	9.76	3.38	6.37
PM	IMM	Spot	83.90	41.94	7.40	50.39	9.99	3.47	6.52
LC	IMM	Forward	82.61	40.81	7.40	49.39	9.80	3.40	6.40
PM	IMM	Forward	84.36	42.35	7.40	50.54	10.05	3.49	6.56

Definition of terms:

LC is least cost method

PM is profit-maximization method

BFP is spot milk prices

SMM is using strips of milk futures to forward contract

IMM is using individual months of milk futures to forward contract

Spot refers to using spot feed prices

Forward refers to using forward feed prices

Table 5.4: Complete Model Statistical Summary

					Averages		
	Milk prod	NEL/day	CP/day	DMI/day	Milk revenues	Feed costs	Profit
LC-BFP-SPOT	82.7486	40.9316	7.4028	49.5413	9.8117	3.4207	6.3910
PM-BFP-SPOT	84.6936	42.6794	7.4028	51.2447	10.1071	3.5401	6.5670
LC-BFP-FORWARD	82.7016	40.8921	7.4028	49.5413	9.8052	3.4096	6.3956
PM-BFP-FORWARD	84.5676	42.5478	7.4028	50.7709	10.0968	3.5123	6.5845
LC-MODEL 1-SPOT	82.3707	40.6171	7.4028	49.3190	9.7536	3.3945	6.3591
PM-MODEL 1-SPOT	83.8873	41.9444	7.4028	50.4224	9.9767	3.4770	6.4997
LC-MODEL 1-FORWARD	82.7546	40.9391	7.4028	49.5866	9.7992	3.4122	6.3871
PM-MODEL 1-FORWARD	84.7308	42.7112	7.4028	50.9354	10.0869	3.5195	6.5674
LC-MODEL 2-SPOT	82.2886	40.5512	7.4028	49.2846	9.7571	3.3823	6.3749
PM-MODEL 2-SPOT	83.9032	41.9448	7.4028	50.3943	9.9924	3.4691	6.5233
LC-MODEL 2-FORWARD	82.6087	40.8081	7.4028	49.3914	9.7996	3.3973	6.4023
PM-MODEL 2-FORWARD	84.3565	42.3518	7.4028	50.5428	10.0510	3.4901	6.5610
				Standard deviations			
LC-BFP-SPOT	4.151932	3.41489	0.960677	4.006348	2.225439	0.400943	2.089919
PM-BFP-SPOT	5.593532	5.022545	0.960677	6.292655	2.689348	0.479175	2.399522
LC-BFP-FORWARD	4.134249	3.400675	0.960671	4.006345	2.21898	0.366547	2.085129
PM-BFP-FORWARD	5.360524	4.736743	0.960671	5.535575	2.715463	0.484542	2.410752
LC-MODEL 1-SPOT	4.055814	3.290831	0.960674	3.640517	1.91162	0.384387	1.811385
PM-MODEL 1-SPOT	5.014872	4.408813	0.960674	5.249261	2.241946	0.445397	2.026077
LC-MODEL 1-FORWARD	4.189289	3.452615	0.960677	4.091624	1.915998	0.372676	1.798402

PM-MODEL 1-FORWARD	5.602409	5.011999	0.960663	5.856479	2.323827	0.48057	2.051474
LC-MODEL 2-SPOT	4.066545	3.291445	0.960666	3.563141	1.968735	0.38352	1.922264
PM-MODEL 2-SPOT	4.884224	4.234171	0.960663	5.007771	2.288545	0.446644	2.131106
LC-MODEL 2-FORWARD	4.02292	3.270289	0.960675	3.741812	1.996247	0.354195	1.936778
PM-MODEL 2-FORWARD	5.168808	4.557957	0.960675	5.323515	2.328684	0.433706	2.145141
				Coefficient of variance			
LC-BFP-SPOT	5.02	8.34	12.98	8.09	22.68	11.72	32.70
PM-BFP-SPOT	6.60	11.77	12.98	12.28	26.61	13.54	36.54
LC-BFP-FORWARD	5.00	8.32	12.98	8.09	22.63	10.75	32.60
PM-BFP-FORWARD	6.34	11.13	12.98	10.90	26.89	13.80	36.61
LC-MODEL 1-SPOT	4.92	8.10	12.98	7.38	19.60	11.32	28.49
PM-MODEL 1-SPOT	5.98	10.51	12.98	10.41	22.47	12.81	31.17
LC-MODEL 1-FORWARD	5.06	8.43	12.98	8.25	19.55	10.92	28.16
PM-MODEL 1-FORWARD	6.61	11.73	12.98	11.50	23.04	13.65	31.24
LC-MODEL 2-SPOT	4.94	8.12	12.98	7.23	20.18	11.34	30.15
PM-MODEL 2-SPOT	5.82	10.09	12.98	9.94	22.90	12.88	32.67
LC-MODEL 2-FORWARD	4.87	8.01	12.98	7.58	20.37	10.43	30.25
PM-MODEL 2-FORWARD	6.13	10.76	12.98	10.53	23.17	12.43	32.70
				Minimums			
LC-BFP-SPOT	73.6537	34.0176	5.4541	41.3008	7.0004	1.3840	3.7366
PM-BFP-SPOT	73.6537	34.0176	5.4541	41.3008	7.0004	2.7049	3.7366
LC-BFP-FORWARD	73.6537	34.0176	5.4541	41.3008	7.0004	2.6613	3.7459
PM-BFP-FORWARD	73.6537	34.0176	5.4541	41.3008	7.0004	2.7101	3.7459
LC-MODEL 1-SPOT	73.6537	34.0176	5.4541	41.3008	7.0004	1.3786	3.7366
PM-MODEL 1-SPOT	73.6537	34.0176	5.4541	41.3008	7.0004	1.5724	3.7366

LC-MODEL 1-FORWARD	73.6537	34.0176	5.4541	41.3008	7.0004	2.6614	3.7459
PM-MODEL 1-FORWARD	73.6537	34.0176	5.4541	41.3008	7.0004	2.7101	3.7459
LC-MODEL 2-SPOT	73.6537	34.0176	5.4541	41.3008	7.0004	1.3840	3.7366
PM-MODEL 2-SPOT	73.6537	34.0176	5.4541	41.3008	7.0004	1.5767	3.7366
LC-MODEL 2-FORWARD	73.6537	34.0176	5.4541	41.3008	7.0004	2.6613	3.7459
PM-MODEL 2-FORWARD	73.6537	34.0176	5.4541	41.3008	7.0004	2.7101	3.7459
					Maximums		
LC-BFP-SPOT	98.2412	55.5783	8.8219	70.3765	17.9341	4.8728	13.0613
PM-BFP-SPOT	103.6658	61.9360	8.8219	73.0465	19.0688	5.3562	14.3111
LC-BFP-FORWARD	98.2412	55.5783	8.8219	70.3765	17.9341	4.8728	13.0613
PM-BFP-FORWARD	103.6302	61.8920	8.8219	73.4625	19.7138	5.6171	14.3229
LC-MODEL 1-SPOT	91.8000	48.8712	8.8219	63.8321	15.3126	5.0530	10.3022
PM-MODEL 1-SPOT	103.4017	61.6103	8.8219	72.2966	16.3972	5.0886	12.3368
LC-MODEL 1-FORWARD	98.2412	55.5783	8.8219	70.3765	15.2141	4.8720	10.3422
PM-MODEL 1-FORWARD	103.6302	61.8920	8.8219	73.4625	16.6659	5.5724	12.4905
LC-MODEL 2-SPOT	91.6424	48.7177	8.8219	63.8321	14.2892	4.7087	11.3403
PM-MODEL 2-SPOT	102.6799	60.7288	8.8219	71.9599	17.1989	5.1709	13.1357
LC-MODEL 2-FORWARD	93.2887	50.3456	8.8219	63.8321	14.6410	4.7087	11.5154
PM-MODEL 2-FORWARD	103.1498	61.3011	8.8219	72.8203	17.1744	5.1878	13.0623
					Ranges		
LC-BFP-SPOT	24.5875	21.5607	3.3678	29.0757	10.9338	3.4888	9.3248
PM-BFP-SPOT	30.0121	27.9184	3.3678	31.7456	12.0684	2.6514	10.5745
LC-BFP-FORWARD	24.5875	21.5607	3.3678	29.0757	10.9338	2.2115	9.3154
PM-BFP-FORWARD	29.9765	27.8744	3.3678	32.1617	12.7134	2.9071	10.5769
LC-MODEL 1-SPOT	18.1463	14.8536	3.3678	22.5312	8.3123	3.6744	6.5656

PM-MODEL 1-SPOT	29.7480	27.5927	3.3678	30.9958	9.3968	3.5162	8.6002
LC-MODEL 1-FORWARD	24.5875	21.5607	3.3678	29.0757	8.2138	2.2106	6.5963
PM-MODEL 1-FORWARD	29.9765	27.8744	3.3678	32.1617	9.6656	2.8623	8.7446
LC-MODEL 2-SPOT	17.9887	14.7001	3.3678	22.5312	7.2888	3.3247	7.6037
PM-MODEL 2-SPOT	29.0262	26.7112	3.3678	30.6590	10.1985	3.5941	9.3991
LC-MODEL 2-FORWARD	19.6350	16.3280	3.3678	22.5312	7.6406	2.0474	7.7694
PM-MODEL 2-FORWARD	29.4961	27.2836	3.3678	31.5195	10.1741	2.4777	9.3164

Table 5.4: Complete Model Statistical Summary (continued)

	Averages															
	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed	Units fed
	Alfalfa Early bloom	Almond Hulls	Barley grain	Beet Pulp	Canola Meal	Corn grain, flaked	Cottonseed, whole fuzzy	Cottonseed Meal 41%	Dried Distillers Grain, corn	Fat	Hominy	Molasses	Rice Bran	Soybean Hulls, pelleted	Soybean Meal 48%	Wheat Middlings
LC-BFP-SPOT	19.84	8.675	0.907	1.224	0.465	2.756	1.752	0.545	3.381	1.142	3.376	0.687	0.346	6.569	0.343	2.997
PM-BFP-SPOT	20.50	9.055	0.933	1.327	0.322	3.452	1.783	0.330	3.350	1.339	3.707	0.737	0.328	6.719	0.182	2.843
LC-BFP-FORWARD	19.84	8.764	0.903	1.279	0.467	2.744	1.635	0.545	3.477	1.126	3.363	0.686	0.346	6.438	0.351	3.043
PM-BFP-FORWARD	20.31	9.001	0.895	1.387	0.360	3.153	1.707	0.434	3.521	1.490	3.459	0.684	0.328	6.480	0.226	2.907
LC-MODEL 1-SPOT	19.75	8.407	0.885	1.225	0.452	2.865	1.620	0.627	3.519	1.146	2.975	0.665	0.837	6.407	0.271	3.096
PM-MODEL 1-SPOT	20.19	8.891	0.903	1.256	0.370	3.135	1.606	0.511	3.650	1.330	3.268	0.714	0.455	6.568	0.186	2.944
LC-MODEL 1-FORWARD	19.86	8.800	0.902	1.225	0.481	2.709	1.675	0.542	3.422	1.130	3.455	0.693	0.346	6.427	0.336	3.053
PM-MODEL 1-FORWARD	20.38	9.055	0.909	1.298	0.335	3.134	1.711	0.397	3.574	1.498	3.585	0.711	0.328	6.498	0.205	2.913
LC-MODEL 2-SPOT	19.73	8.471	0.894	1.214	0.486	2.727	1.659	0.599	3.539	1.142	2.798	0.660	0.906	6.497	0.259	3.121
PM-MODEL 2-SPOT	20.17	8.844	0.895	1.239	0.359	3.143	1.680	0.459	3.684	1.329	3.064	0.724	0.378	6.610	0.166	3.208
LC-MODEL 2-FORWARD	19.77	8.673	0.918	1.230	0.438	3.019	1.645	0.618	3.703	1.141	2.930	0.684	0.394	6.182	0.250	3.250
PM-MODEL 2-FORWARD	20.22	8.885	0.942	1.273	0.323	3.273	1.647	0.509	3.672	1.486	3.113	0.737	0.361	6.274	0.172	3.223
	Standard deviations															
LC-BFP-SPOT	1.61	5.457	1.240	3.903	1.064	4.028	4.032	1.231	4.743	0.601	4.347	0.672	2.041	9.054	1.016	4.795
PM-BFP-SPOT	2.52	5.784	1.312	4.137	0.949	5.408	4.052	1.064	4.779	0.501	4.731	0.711	2.040	9.168	0.789	4.756
LC-BFP-FORWARD		5.407	1.236	3.985	1.062	4.031	3.929	1.231	4.831	0.612	4.321	0.672	2.041	8.908	1.018	4.830

	1.61															
PM-BFP-FORWARD	2.22	5.667	1.238	4.366	1.009	5.302	3.993	1.201	4.956	0.261	4.559	0.686	1.977	9.022	0.848	4.716
LC-MODEL 1-SPOT	1.48	5.436	1.235	3.837	1.142	4.488	3.904	1.459	5.011	0.600	3.910	0.665	3.652	9.093	0.932	5.250
PM-MODEL 1-SPOT	2.11	5.593	1.241	3.812	1.053	5.015	3.891	1.396	5.098	0.493	4.313	0.703	2.211	9.102	0.787	5.134
LC-MODEL 1-FORWARD	1.64	5.437	1.237	3.902	1.155	3.967	3.947	1.230	4.822	0.609	4.411	0.673	2.041	8.858	0.993	4.838
PM-MODEL 1-FORWARD	2.34	5.734	1.241	4.093	0.993	5.208	3.987	1.174	5.044	0.264	4.715	0.690	1.977	9.022	0.803	4.726
LC-MODEL 2-SPOT	1.43	5.354	1.233	3.812	1.321	4.281	3.938	1.448	5.047	0.601	3.739	0.659	3.904	9.188	0.948	5.250
PM-MODEL 2-SPOT	2.01	5.589	1.237	3.801	1.096	5.062	3.960	1.388	5.229	0.491	4.151	0.685	2.133	9.295	0.756	5.608
LC-MODEL 2-FORWARD	1.50	5.360	1.304	3.809	1.132	4.898	3.927	1.513	5.192	0.606	3.881	0.662	2.136	8.930	0.868	5.608
PM-MODEL 2-FORWARD	2.13	5.600	1.345	3.814	1.006	5.477	3.941	1.499	5.228	0.252	4.225	0.695	2.039	9.005	0.759	5.590
	Coefficient of variance															
LC-BFP-SPOT	8.11	62.90	136.71	318.74	229.10	146.16	230.17	226.00	140.28	52.62	128.79	97.89	589.46	137.83	296.07	160.01
PM-BFP-SPOT	12.28	63.88	140.63	311.80	295.06	156.68	227.20	321.94	142.64	37.41	127.62	96.40	621.41	136.44	433.60	167.31
LC-BFP-FORWARD	8.11	61.70	136.93	311.60	227.29	146.89	240.27	226.13	138.94	54.38	128.48	97.88	589.48	138.37	289.97	158.76
PM-BFP-FORWARD	10.91	62.96	138.38	314.70	280.05	168.16	233.97	276.98	140.73	17.53	131.81	100.29	601.83	139.23	374.49	162.23
LC-MODEL 1-SPOT	7.48	64.66	139.56	313.21	252.67	156.64	240.95	232.93	142.41	52.38	131.44	99.98	436.04	141.93	343.52	169.61
PM-MODEL 1-SPOT	10.45	62.91	137.38	303.57	284.25	159.95	242.35	273.41	139.68	37.10	131.97	98.34	486.07	138.58	423.72	174.40
LC-MODEL 1-FORWARD	8.27	61.78	137.16	318.47	240.05	146.41	235.72	226.94	140.90	53.94	127.67	97.13	589.27	137.82	295.62	158.48
PM-MODEL 1-FORWARD	11.50	63.33	136.58	315.24	296.84	166.16	232.93	295.73	141.11	17.60	131.50	97.05	602.21	138.84	391.94	162.23
LC-MODEL 2-SPOT	7.25	63.21	138.01	313.98	271.51	157.00	237.36	241.71	142.63	52.59	133.63	99.96	430.74	141.42	365.64	168.21
PM-MODEL 2-SPOT	9.95	63.20	138.15	306.66	305.51	161.03	235.75	302.25	141.96	36.93	135.48	94.62	563.70	140.62	454.33	174.79
LC-MODEL 2-FORWARD	7.59	61.80	141.97	309.63	258.24	162.27	238.67	244.81	140.20	53.13	132.46	96.76	541.69	144.46	347.31	172.59
PM-MODEL 2-FORWARD	10.54	63.03	142.82	299.61	311.65	167.35	239.38	294.42	142.37	16.94	135.74	94.29	564.30	143.53	441.07	173.41

	Minimums															
LC-BFP-SPOT	16.52	0.000	0.000	0.000	0.000	0.000	-0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.009	0.000
PM-BFP-SPOT	16.52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LC-BFP-FORWARD	16.52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PM-BFP-FORWARD	16.52	0.000	-0.006	0.000	0.000	0.000	0.000	0.000	-0.003	0.000	0.000	0.000	0.000	0.000	-0.008	0.000
LC-MODEL 1-SPOT	16.52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000
PM-MODEL 1-SPOT	16.52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.005	0.000	0.000	0.000
LC-MODEL 1-FORWARD	16.52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.009	0.000
PM-MODEL 1-FORWARD	16.52	0.000	-0.005	0.000	0.000	0.000	0.000	0.000	-0.003	0.000	0.000	-0.003	0.000	0.000	-0.010	0.000
LC-MODEL 2-SPOT	16.52	0.000	0.000	0.000	-0.007	0.000	-0.003	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000
PM-MODEL 2-SPOT	16.52	0.000	0.000	0.000	0.000	0.000	0.000	-0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.007
LC-MODEL 2-FORWARD	16.52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PM-MODEL 2-FORWARD	16.52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Maximums															
LC-BFP-SPOT	28.15	17.594	6.585	29.141	6.746	29.261	17.133	8.011	21.369	1.644	17.596	1.949	24.087	37.061	5.171	23.880
PM-BFP-SPOT	29.21	18.262	8.288	29.141	6.719	32.730	17.133	8.011	21.876	2.191	18.212	2.186	24.087	34.803	5.043	23.880
LC-BFP-FORWARD	28.15	17.594	6.585	29.141	6.746	29.261	17.133	8.011	21.369	1.644	17.596	1.949	24.087	37.061	5.171	25.042
PM-BFP-FORWARD	29.39	18.366	6.585	29.141	6.719	29.261	17.133	8.011	21.190	2.204	18.367	2.066	22.624	34.693	5.043	25.042
LC-MODEL 1-SPOT	25.58	15.875	6.585	29.141	7.746	29.261	17.133	8.468	21.387	1.644	13.708	1.785	24.847	37.093	5.084	29.475
PM-MODEL 1-SPOT	28.92	18.074	6.585	29.141	7.745	29.261	17.133	8.468	21.442	2.169	18.022	2.169	24.296	35.292	5.043	30.042
LC-MODEL 1-FORWARD	28.15	17.594	6.585	29.141	8.958	29.261	17.133	8.011	21.392	1.644	17.596	1.949	24.087	35.692	5.188	25.042
PM-MODEL 1-FORWARD	29.39	18.366	6.585	29.141	7.004	29.261	17.133	8.011	21.442	2.204	18.367	2.157	22.624	35.024	5.043	25.042
LC-MODEL 2-SPOT	25.58	15.875	6.585	29.141	9.391	29.261	17.133	8.468	21.387	1.644	13.359	1.776	24.847	37.108	5.367	29.475
PM-MODEL 2-SPOT		17.990	6.585	29.141	7.778	29.261	17.133	8.468	21.387	2.159	17.990	2.159	24.296	37.843	5.043	30.042

	28.78															
LC-MODEL 2-FORWARD	25.58	15.875	7.768	29.141	7.778	33.961	17.133	8.468	21.387	1.644	15.865	1.904	24.296	37.105	5.084	30.042
PM-MODEL 2-FORWARD	29.13	18.205	9.502	29.141	7.778	32.649	17.133	9.067	21.710	2.185	18.205	2.185	22.712	35.306	5.043	30.061
	Ranges															
LC-BFP-SPOT	11.63	17.594	6.585	29.141	6.746	29.261	17.142	8.011	21.369	1.644	17.596	1.949	24.087	37.061	5.180	23.880
PM-BFP-SPOT	12.69	18.262	8.288	29.141	6.719	32.730	17.133	8.011	21.876	2.191	18.212	2.186	24.087	34.803	5.043	23.880
LC-BFP-FORWARD	11.63	17.594	6.585	29.141	6.746	29.261	17.133	8.011	21.369	1.644	17.596	1.949	24.087	37.061	5.171	25.042
PM-BFP-FORWARD	12.86	18.366	6.591	29.141	6.719	29.261	17.133	8.011	21.193	2.204	18.367	2.066	22.624	34.693	5.051	25.042
LC-MODEL 1-SPOT	9.06	15.875	6.585	29.141	7.746	29.261	17.133	8.468	21.387	1.645	13.708	1.785	24.847	37.093	5.084	29.475
PM-MODEL 1-SPOT	12.40	18.074	6.585	29.141	7.745	29.261	17.133	8.468	21.442	2.169	18.022	2.169	24.301	35.292	5.043	30.042
LC-MODEL 1-FORWARD	11.63	17.594	6.585	29.141	8.958	29.261	17.133	8.011	21.392	1.644	17.596	1.949	24.087	35.692	5.197	25.042
PM-MODEL 1-FORWARD	12.86	18.366	6.590	29.141	7.004	29.261	17.133	8.011	21.445	2.204	18.367	2.160	22.624	35.024	5.053	25.042
LC-MODEL 2-SPOT	9.06	15.875	6.585	29.141	9.398	29.261	17.136	8.468	21.387	1.645	13.359	1.776	24.847	37.108	5.367	29.475
PM-MODEL 2-SPOT	12.26	17.990	6.585	29.141	7.778	29.261	17.133	8.473	21.387	2.159	17.990	2.159	24.296	37.843	5.043	30.049
LC-MODEL 2-FORWARD	9.06	15.875	7.768	29.141	7.778	33.961	17.133	8.468	21.387	1.644	15.865	1.904	24.296	37.105	5.084	30.042
PM-MODEL 2-FORWARD	12.61	18.205	9.502	29.141	7.778	32.649	17.133	9.067	21.710	2.185	18.205	2.185	22.712	35.306	5.043	30.061

Table 5.5: Average Daily Profit Statistical Summary

Code	Strategy	Ave profit $/day	Standard deviation	Coefficent of variation	Maximum	Minimum	Range
A	LC-BFP-SPOT	6.3910	2.09	32.70	13.06	3.74	9.32
B	PM-BFP-SPOT	6.5670	2.40	36.54	14.31	3.74	10.57
C	LC-BFP-FORWARD	6.3956	2.09	32.60	13.06	3.75	9.32
D	PM-BFP-FORWARD	6.5845	2.41	36.61	14.32	3.75	10.58
E	LC-SMM-SPOT	6.3591	1.81	28.49	10.30	3.74	6.57
F	PM-SMM-SPOT	6.4997	2.03	31.17	12.34	3.74	8.60
G	LC-SMM-FORWARD	6.3871	1.80	28.16	10.34	3.75	6.60
H	PM-SMM-FORWARD	6.5674	2.05	31.24	12.49	3.75	8.74
I	LC-IMM-SPOT	6.3749	1.92	30.15	11.34	3.74	7.60
J	PM-IMM-SPOT	6.5233	2.13	32.67	13.14	3.74	9.40
K	LC-IMM-FORWARD	6.4023	1.94	30.25	11.52	3.75	7.77
L	PM-IMM-FORWARD	6.5610	2.15	32.70	13.06	3.75	9.32

Definition of terms:

LC is least cost method

PM is profit-maximization method

BFP is spot milk prices

SMM is using strips of milk futures to forward contract

IMM is using individual months of milk futures to forward contract

Spot refers to using spot feed prices

Forward refers to using forward feed prices

Figure 5.1: Average Daily Net Return by Management Strategy ($/day)

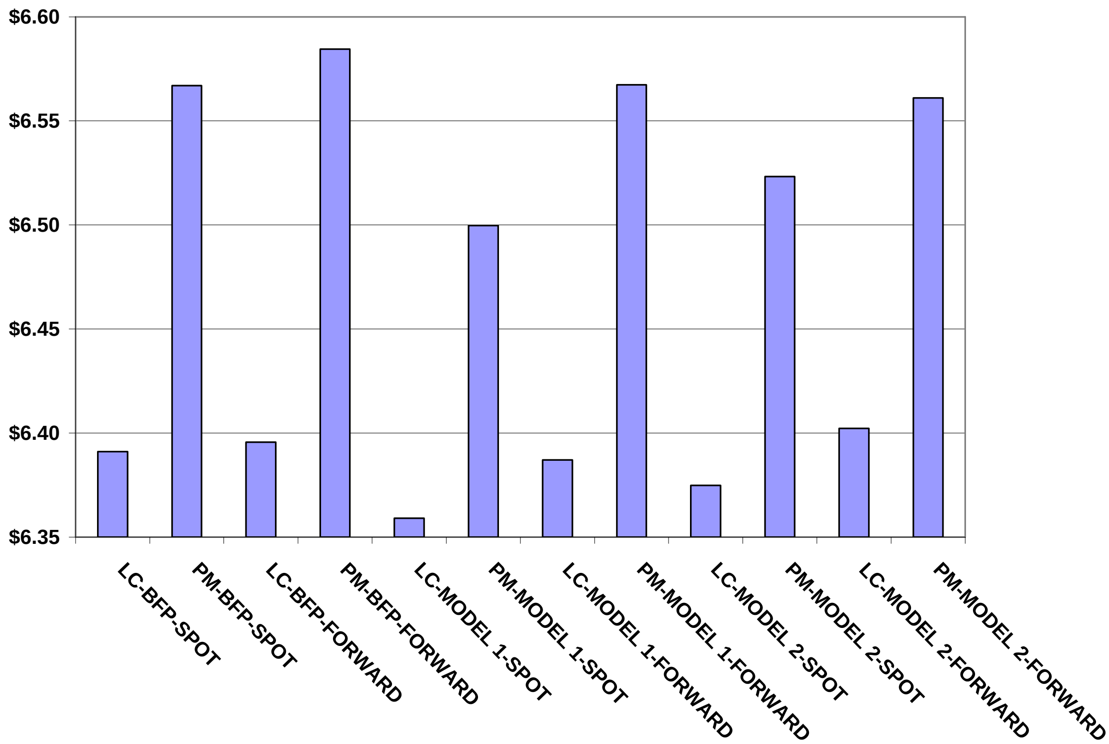
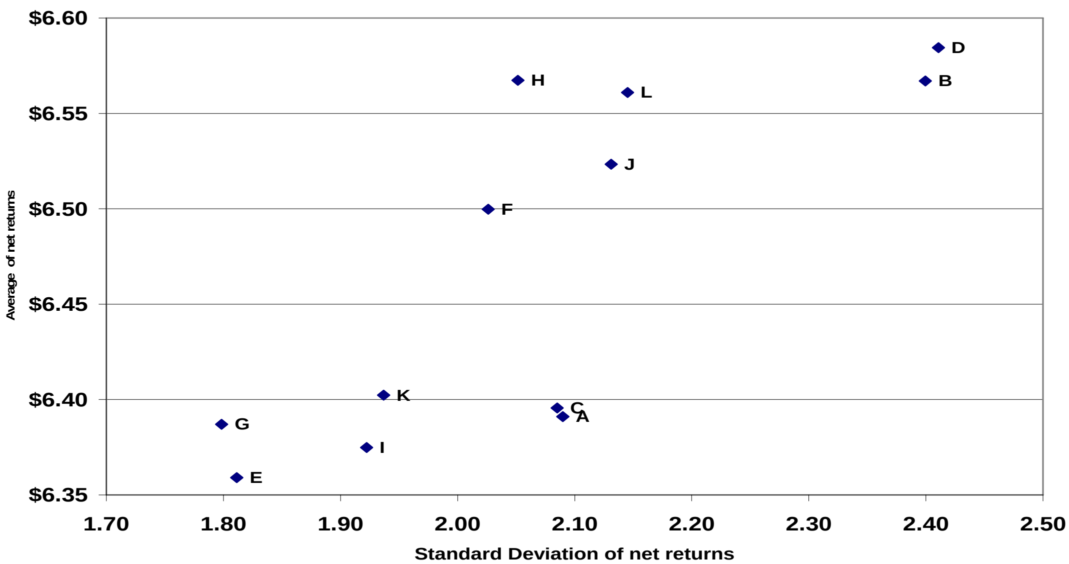


Figure 5.2: Efficient Frontier, Average Net Return in $/day vs. Standard Deviation



Legend

Code	Ration	Milk Price	Feed Price
A	LC	BFP	SPOT
B	PM	BFP	SPOT
C	LC	BFP	FORWARD
D	PM	BFP	FORWARD
E	LC	SMM	SPOT
F	PM	SMM	SPOT
G	LC	SMM	FORWARD
H	PM	SMM	FORWARD
I	LC	IMM	SPOT
J	PM	IMM	SPOT

CHAPTER VI: SUMMARY AND CONCLUSIONS

6.1 Summary of Thesis Objectives

The main objective of this research was to compare the net returns of price risk management tools available to dairy producers using least-cost and profit-maximization models. The feed price results for nine of the ingredients that could be forward contracted indicated four had lower average prices when forward contracting was used as opposed to taking the spot market price. Five had higher average prices using spot prices as compared to forward contracting. Five of the nine ingredients that could be forward contracted had lower coefficients of variation when contracted than their respective spot prices.

Perhaps the best strategy to select when deciding whether to use spot or forward feed values is forward contracting those feed ingredients that have exhibited a large amount of price variability in the past. Figure 6.1 shows the coefficient of variation for 15 of the feed ingredients used in the models during the study period August 1999 to September 2004. The low CV was for beet pulp shreds at 6.75 with soybean meal having the highest CV at 19.87. The protein meals in general had the highest coefficient of variation values. Canola meal, cottonseed meal, and soybean meal are the protein meals most commonly fed and had CV's of 14.76, 16.62, and 19.87, respectively.

The ration formulation models used three different milk price series: BFP Class III cash price, Strips Months Model (SMM) that used the 3, 6, or 12 months strips of Class III milk futures, or the Individual Months Model (IMM). The highest average milk price was the spot value. It exceeded the forward contracted price for both the SMM and IMM models. On the other hand, both the SMM and IMM milk values had lower price volatility as measured by the coefficient of variation. For a dairy producer, the benefits of forward contracting with a more stable, albeit slightly lower, milk price may prove to be preferable than just taking the spot milk price with its greater volatility.

The results show that producers achieve higher net returns using spot milk prices regardless of whether they use the least-cost or profit-maximization methods in seven of the eight scenarios vs. forward contracted milk prices. The only exception was higher returns for a producer using the IMM milk prices, forward feed values, and least-cost formulation (LC-IMM-FORWARD vs. LC-BFP-FORWARD). The variance in net returns as measured by the coefficient of variation was higher using spot milk prices vs. either IMM or SMM milk prices regardless whether the producer used spot or forward feed values and either the least-cost or profit-maximization methods. The choice of forward contracting milk is also dependent on the financial situation of that particular enterprise, how much if any forward contracting has been done on the feed side and ones expectations about the future direction of milk prices.

The rations with both forward and spot feed and milk prices using either the least-cost or profit-maximization models were solved. In all cases, the profit-maximization approach yielded higher average daily net returns. The profit-maximization rations also had higher net return volatility as measured by the standard deviation than all least-cost strategies regardless of whether feed and milk prices were spot or forward contracted. Nonetheless, there were some profit-maximization strategies that offered a combination of high returns and lower standard deviations than least-cost strategies. The PM-SMM-SPOT strategy has higher net returns and a lower standard deviation than strategies LC-BFP-SPOT and LC-BFP-FORWARD. The PM-SMM-FORWARD strategy is also better than LC-BFP-SPOT and LC-BFP-FORWARD. The highest daily returns were achieved by the

PM-BFP-FORWARD strategy. However, this scenario also had the highest risk while a least-cost model, LC-SMM-FORWARD had the lowest risk.

In summary, the profit-maximization approach achieved higher net returns than the least-cost approach regardless of spot and forward feed and milk prices. Net returns were higher for strategies that used spot milk prices as opposed to forward contracted milk values in seven of eight cases while returns were higher for those scenarios where forward contracts as opposed to spot feed prices were used regardless of milk prices or formulation method.

6.2 Limitations of the Research

There were a number of challenges involved with this research including trying to model how producers would react to different feed and milk pricing strategies. For this paper, certain assumptions had to be made and not all of these may accurately reflect a typical producer's behavior. An example of this is the assumption that a producer would want to lock in a favorable feed or milk price for as long as possible. Under the feed contracting guidelines, given the choice between locking in a feed contract for three months or a clock contract for a longer period of time, the criteria was to use the longer-term contract. It may be that a producer would actually opt to lock in a particular feed ingredient for a shorter period of time, hoping that both spot and forward values move lower. Similarly on the milk side, the criteria used had the producer lock in larger increments of future milk production the longer the forward contract was in place. The Strips Method Model (SMM) had a producer lock in 25% of their future milk production if the three month strip of futures was above the benchmark price defined as the rolling five-year Class III milk price plus one standard deviation. If the six-month strip was above the benchmark then 33% of future milk would be locked in and if the 12-month strip of futures was above the benchmark then 50% of the next 12 months of milk would be sold at that level. However, a producer may decide to take the opposite approach and contract a smaller percentage of future milk production at the six-month and 12-month strip levels. This may be based on some concern about locking in milk at prices levels that may be lower than what actually materializes.

Another limitation of the research was deciding what the forward contracting criteria should be. California dairy producers have no hard and fast rules for forward contracting either feed or milk. For milk, this thesis used both strips of futures or individual months but in order to forward contract, values had to be over the specified benchmark of the rolling five-year average Class III milk price plus one standard deviation. In light of the fact that for the SMM model was only used in 29.5% of the weeks in the 264-week study period and the IMM was used only 26.9% of the time the benchmarks may have to be revised in order to create more forward contracting opportunities. Similarly, for forward contracting feed, some ingredients such as cottonseed and corn had numerous forward contracting opportunities while other products such as cottonseed meal and soyhull pellets had limited opportunities. Further, since the study period ended in August 2004; the surge in feed prices would have resulted in very few chances to forward contract any ingredient using the criteria of the rolling five year average less one-half a standard deviation. On the other hand, milk prices have continued their volatile price behavior resulting in a multitude of opportunities to forward contract milk. This would have resulted in producers locking in milk yet leaving the feed side open. Contracting strategies designed to lock in a positive margin may be another alternative to examine.

6.3 Suggestions for Additional Research

Since the study period for this paper has ended, the additional data would allow more of the chosen feed ingredients to be included in the forward contracting section. A larger problem is that dynamic events in the world grain and oilseed situation has caused many of the analyzed feed ingredient prices to move to their highest price levels in years with many values either at or recently attaining all-time highs. Crop shortfalls in a number of major producing areas throughout the globe, increased demand in many of the developing nations, and a dramatic rise in the utilization of crops for renewable fuels has sent stocks of the major food and feed grains to their lowest levels in decades. Prices of many key agricultural commodities such as corn, wheat, and soybeans are now at multi-year highs and in the process caused the price of many by-products commonly fed to also increase. With the forward contracting benchmark for feed ingredients being the rolling five-year average less one-half a standard deviation, any opportunities to forward contract would be few and far between. This does not appear to be a temporary situation as the need to keep row crop prices high to attract sufficient planted acreage and the importance of building grain stocks to more comfortable levels suggests that feed ingredients will trade at levels well above their historical norms for the foreseeable future..

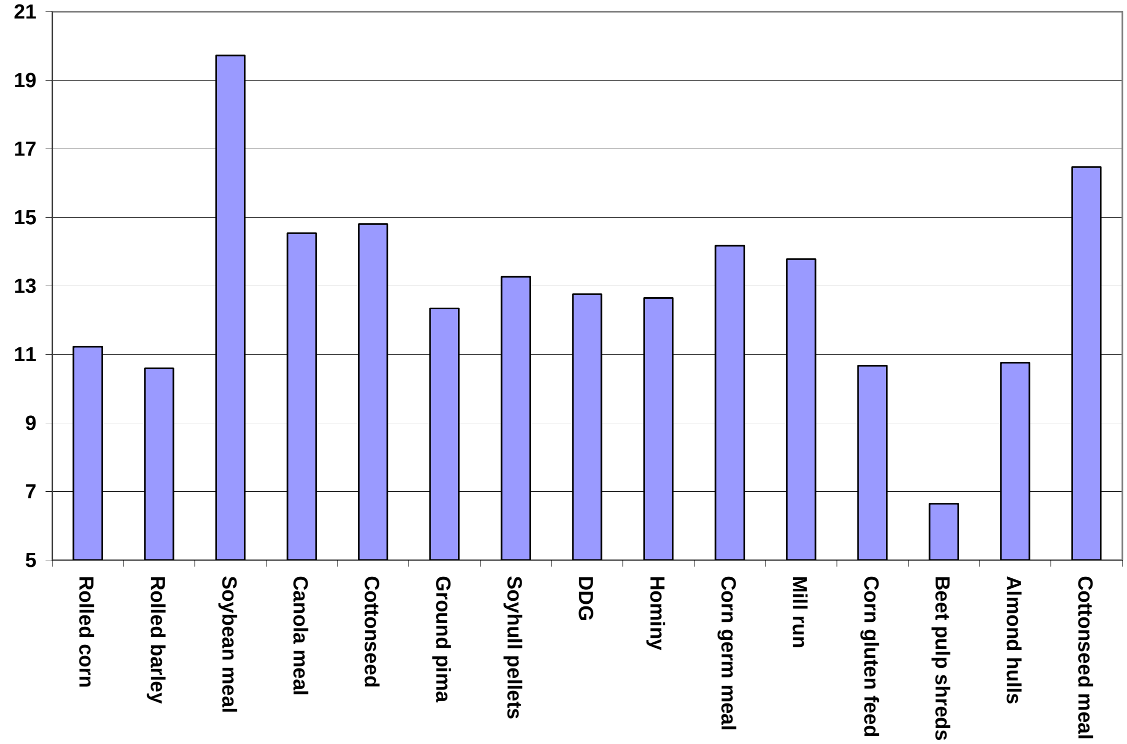
Since the study period for this paper ending in August 2004, volatility in milk prices has continued unabated, perhaps at an even more extreme level. Class III prices dipped as low as $10.83 in May of 2006 before rebounding in the summer of 2007 with the July Class III at a new all-time high of $21.38. Along with the usual vicissitudes of supply and demand, price volatility has been exacerbated by milk production declines in Australia and the European Union along with burgeoning demand for various fractionated milk products. These developments have accentuated the need for dairy producers to understand

and use the various price risk management strategies available to them. Unfortunately for a variety of reasons, California dairy producers remain skittish about forward contracting milk. A lack of understanding, fear of leaving money on the table, and ideas that what would appear to be a favorable forward milk price is not as attractive now as in the past has limited participation. The criteria used for SMM and IMM milk prices could also be refined. Recent milk price activity has witnessed extreme peaks and valleys. The lower milk prices seen by both forward contracting models vs. spot values is due to the fact that when cash milk prices are on an upswing, they run to levels far higher than those of the defined benchmark, in this case the five-year rolling average plus one standard deviation.

The final point on additional research is the still limited use of the profit-maximization algorithm in today's dairy ration formulation programs. This may be due to uncertainty as to how the Federal Market Class III and IV prices are correlated with the mailbox prices received by individual producers throughout the country and a belief that maximizing milk production is the best way to maximize profits. With regard to this latter point, the results in this paper do demonstrate that maximum milk production does generate maximum profits. Another consideration is that while maximizing milk production and component levels (% of protein and milk-fat) is a major influence in formulating a ration, there are other factors. Among them is the need to allow the cow to get pregnant, develop the fetus, avoid any feeding disorders, and help transition the animal into her dry period. Still, the use of a profit-maximization model allows a producer and nutritionist to fix profitable margins well into the future and study an array of shadow feed and milk prices that can also incrementally increase profits. The ration developed here is rather rudimentary as a more sophisticated program would formulate based on not just net energy and crude protein requirements but also on more detailed considerations such as digestibility factors, amino acid levels, and fiber portions.

A final point is that the increased price variability in both feed and milk prices are not only taxing the management skills of today's dairy producers but threatening the viability of the operation itself. In 2009, many California dairy producers experienced an unprecedented period of time where milk revenues ($/cwt) of milk produced did not even cover the costs of the feed needed to support that level of milk production. This has resulted in a complete erosion of equity and unparalleled levels of financial and emotional distress on today's operators. In 2009 it was reported (CDFA 2009, USDA 2010) that many California dairy producers lost $100-150/month per cow, at least 100 dairies went out of business, and for the first time in over 40 years, milk cow numbers in the state declined by 40,000 cows. In this environment, dairy producers and their lenders will find it necessary to use risk management principles to manage the inherent price risk in their business. Furthermore, it is no longer sufficient to fix feed costs or milk prices for producers will have to do both and hope to lock in profitable or at least break-even margins going forward.

Figure 6.1: Coefficient of Variation Figures for Common Feed Ingredients, Aug 1999-Nov 2004



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